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(54) **NO-TOUCH SURGICAL NAVIGATION METHOD AND SYSTEM THEREOF**

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CPC ***A61B 34/20*** (2016.02); ***G06K 9/6201*** (2013.01); ***G06T 7/0014*** (2013.01); ***G06T 7/248*** (2017.01);
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CPC A61B 34/20; A61B 2034/2055; A61B 2034/2061; A61B 2034/2065; G06T 7/80;
(Continued)

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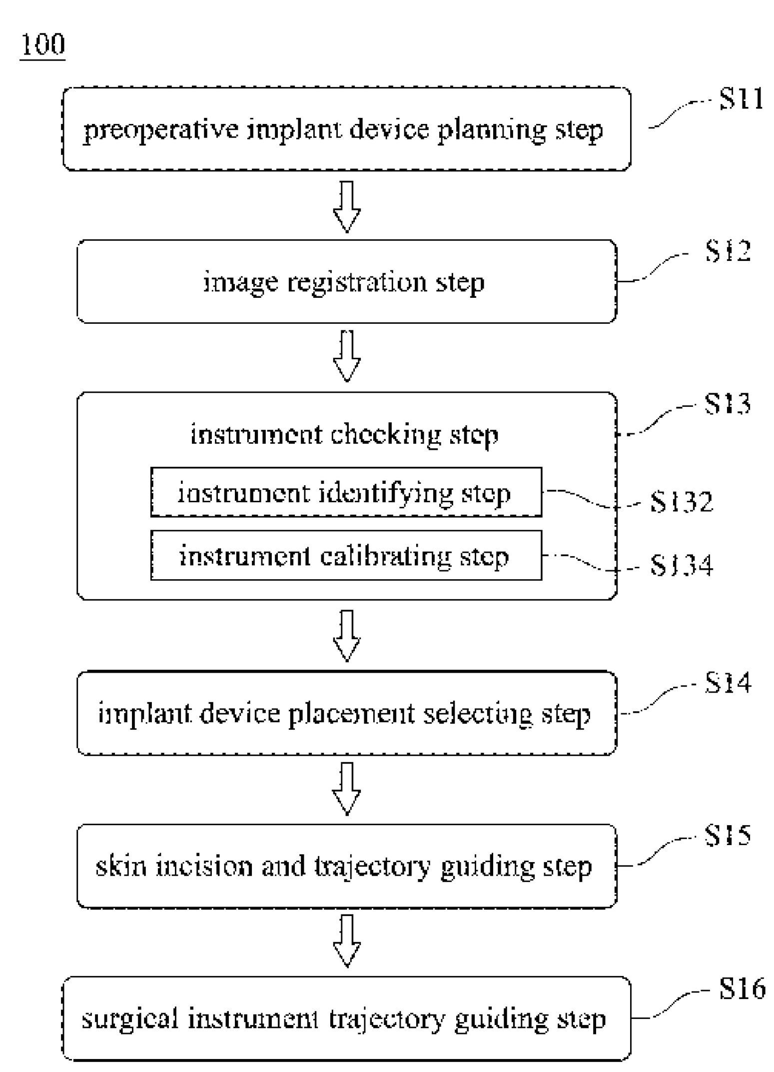
(57) **ABSTRACT**

A no-touch surgical navigation method for guiding a surgical instrument corresponding to a part of a patient's anatomy is provided. An image registration step is for matching the preoperative implant device planning image and the part of the patient's anatomy via a spatial coordinate transformation relationship. An instrument checking step is for identifying the surgical instrument, and then calibrating a size of the surgical instrument to display an instrument tip mark on the displaying device. An implant device placement selecting step is for moving the surgical instrument by a user, and then the instrument tip mark is synchronously moved with the surgical instrument to select a virtual surgical instrument pattern. A skin incision and trajectory guiding step is for moving the surgical instrument according to a skin incision and trajectory guiding picture so as to move the instrument tip mark close to a planned surgical position.

26 Claims, 17 Drawing Sheets



(51) **Int. Cl.**

G06T 7/246	(2017.01)
G06T 7/33	(2017.01)
G06T 7/80	(2017.01)
G06K 9/62	(2006.01)
G06T 7/00	(2017.01)
G06T 11/00	(2006.01)

(52) **U.S. Cl.**

CPC ***G06T 7/337*** (2017.01); ***G06T 7/80*** (2017.01); ***G06T 11/003*** (2013.01); *A61B 2034/2055* (2016.02); *A61B 2034/2061* (2016.02); *A61B 2034/2065* (2016.02); *G06K 2209/057* (2013.01); *G06T 11/001* (2013.01); *G06T 2207/10116* (2013.01); *G06T 2207/30052* (2013.01); *G06T 2207/30088* (2013.01); *G06T 2207/30241* (2013.01)

(58) **Field of Classification Search**

CPC G06T 7/337; G06T 7/248; G06T 7/0014; G06T 11/003; G06T 11/001; G06T 2207/10116; G06T 2207/30052; G06T 2207/30088; G06T 2207/30241; G06K 9/6201; G06K 2209/057

See application file for complete search history.

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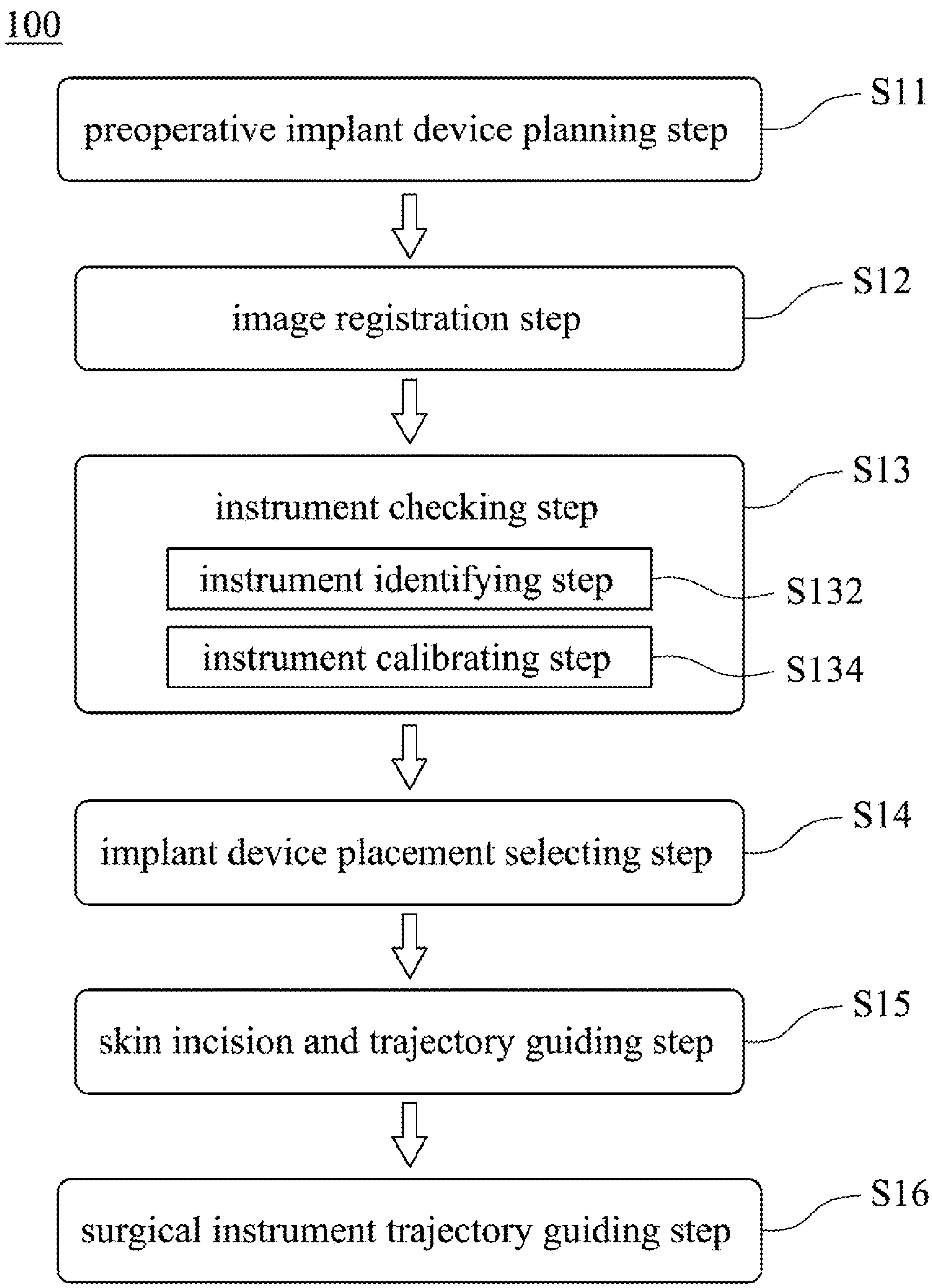
100
preoperative implant device planning step
S11
image registration step
S12
instrument checking step
S13
instrument identifying step
S132
instrument calibrating step
S134
implant device placement selecting step
S14
skin incision and trajectory guiding step
S15
surgical instrument trajectory guiding step
S16

Fig. 1

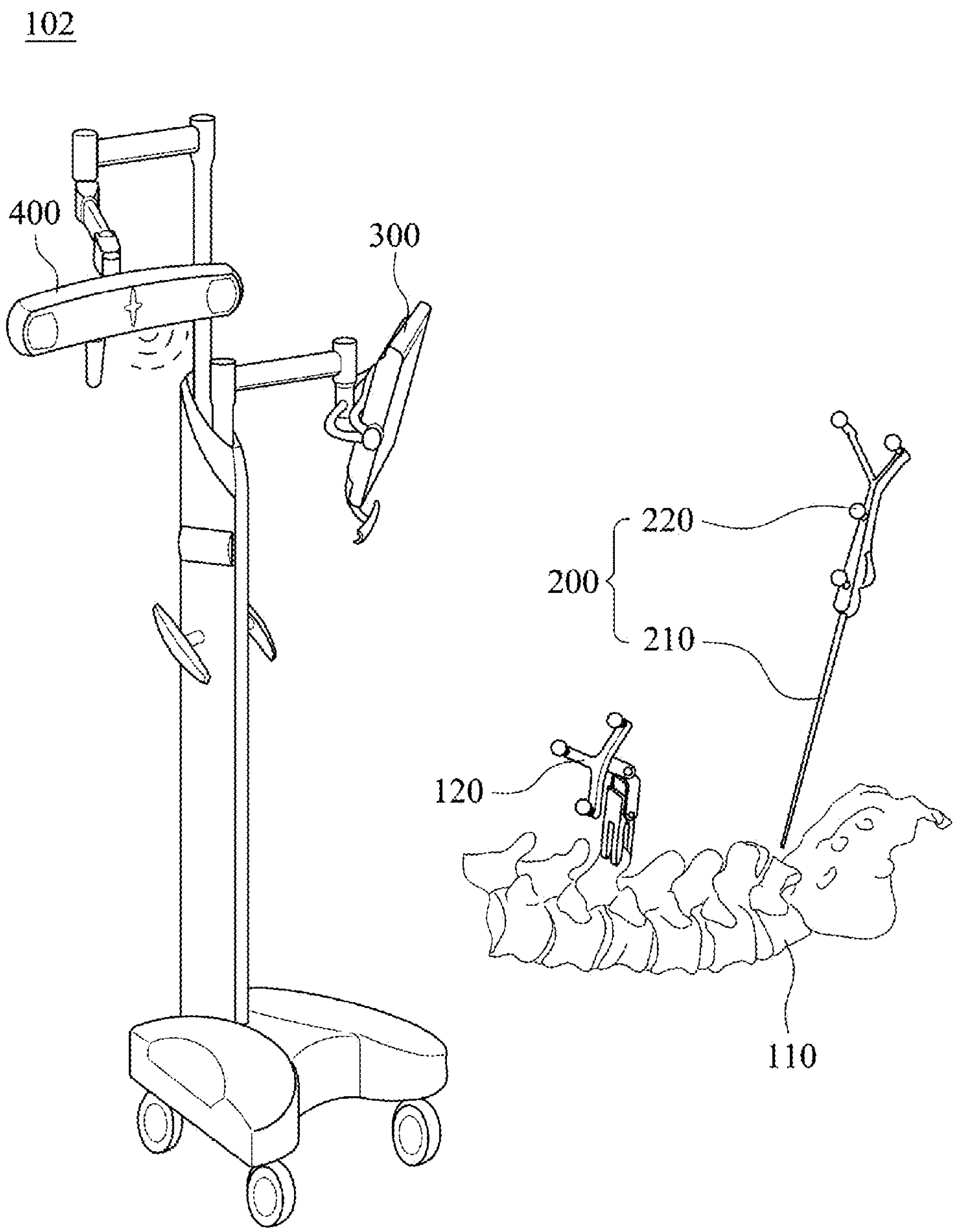

Fig. 2A

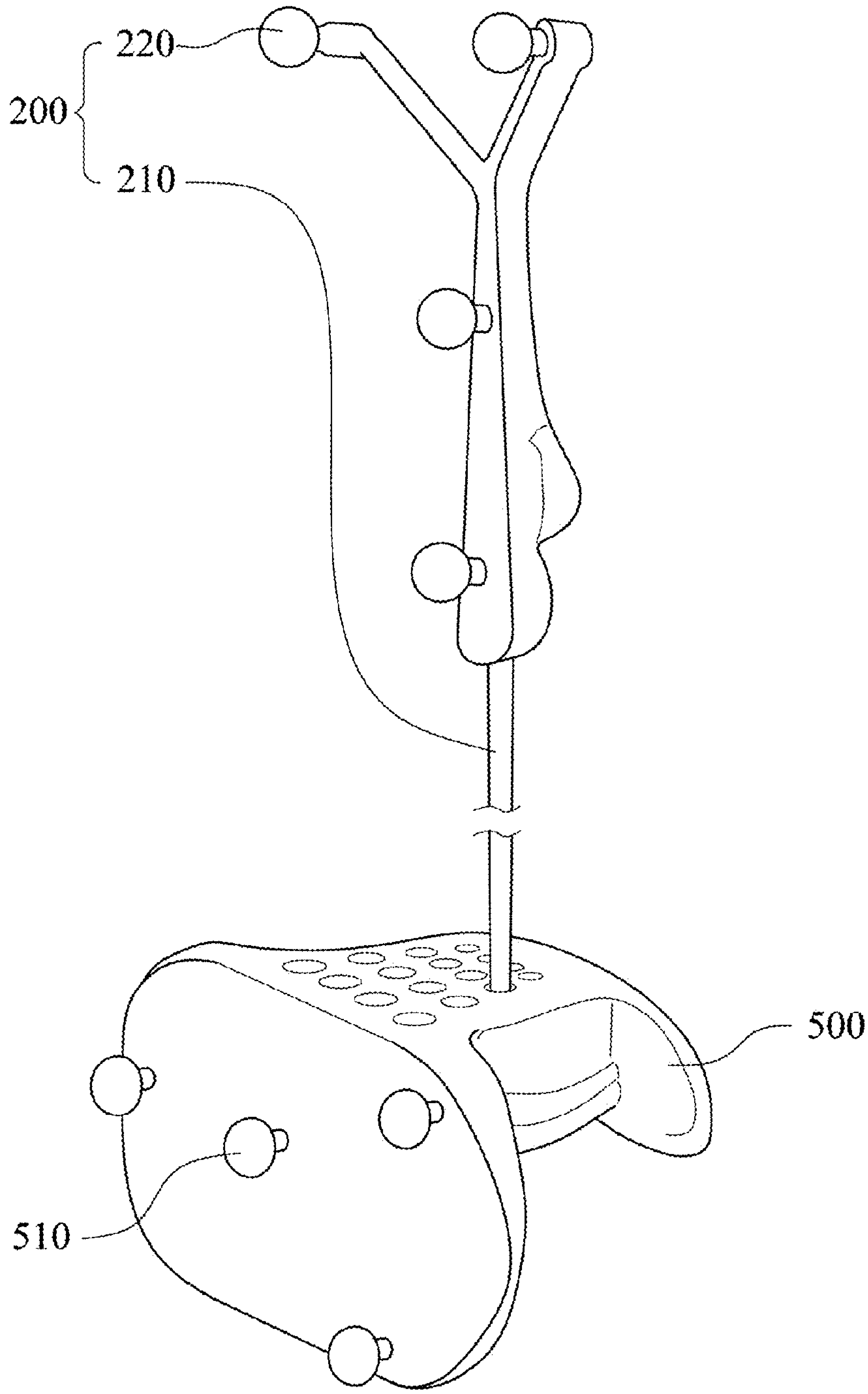

Fig. 2B

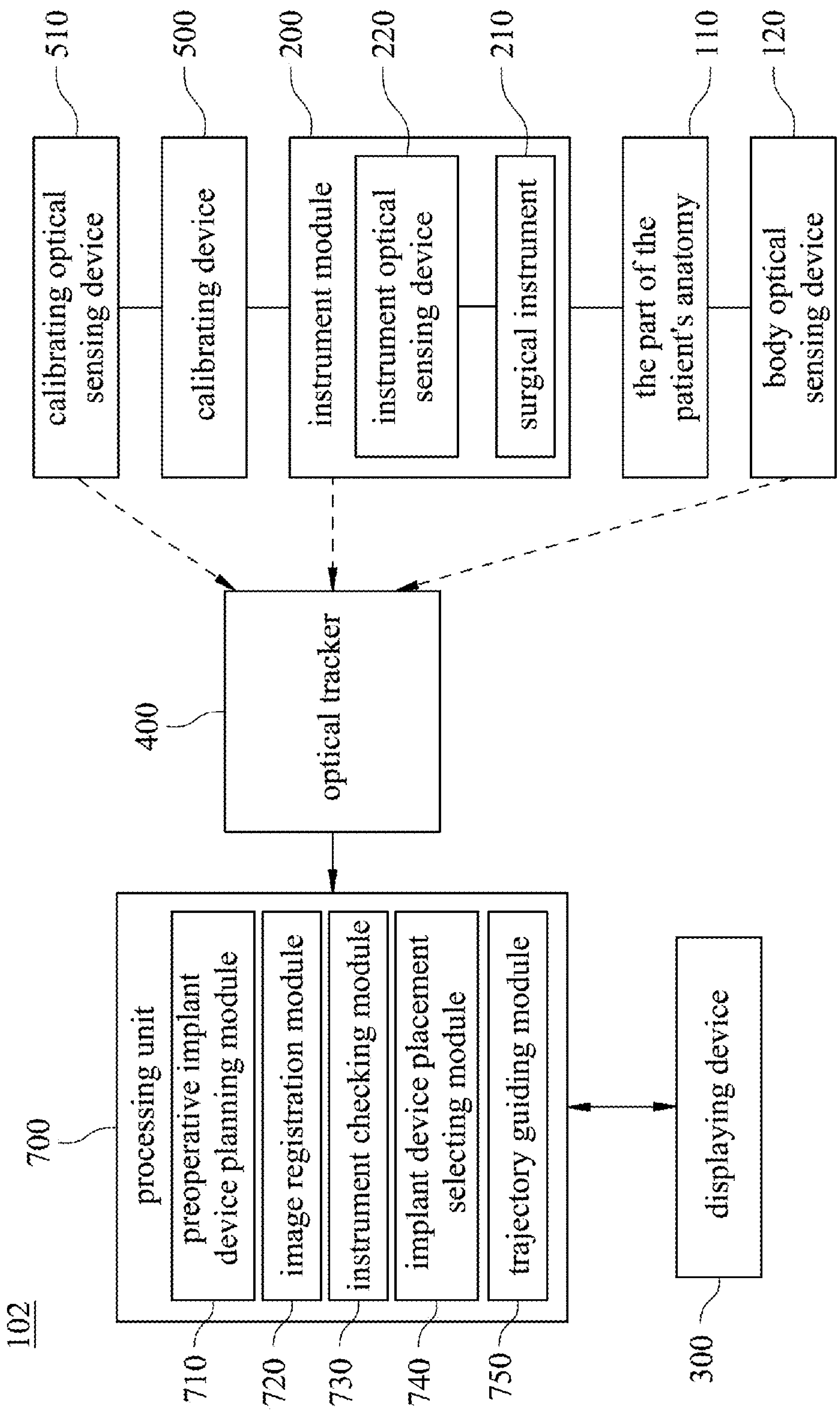
510
500
200
220
210
110
120
calibrating optical sensing device
calibrating device
instrument module
instrument optical sensing device
surgical instrument
the part of the patient's anatomy
body optical sensing device
400
optical tracker
700
processing unit
preoperative implant device planning module
image registration module
instrument checking module
implant device placement selecting module
trajectory guiding module
displaying device
102
710
720
730
740
750
300

Fig. 2C

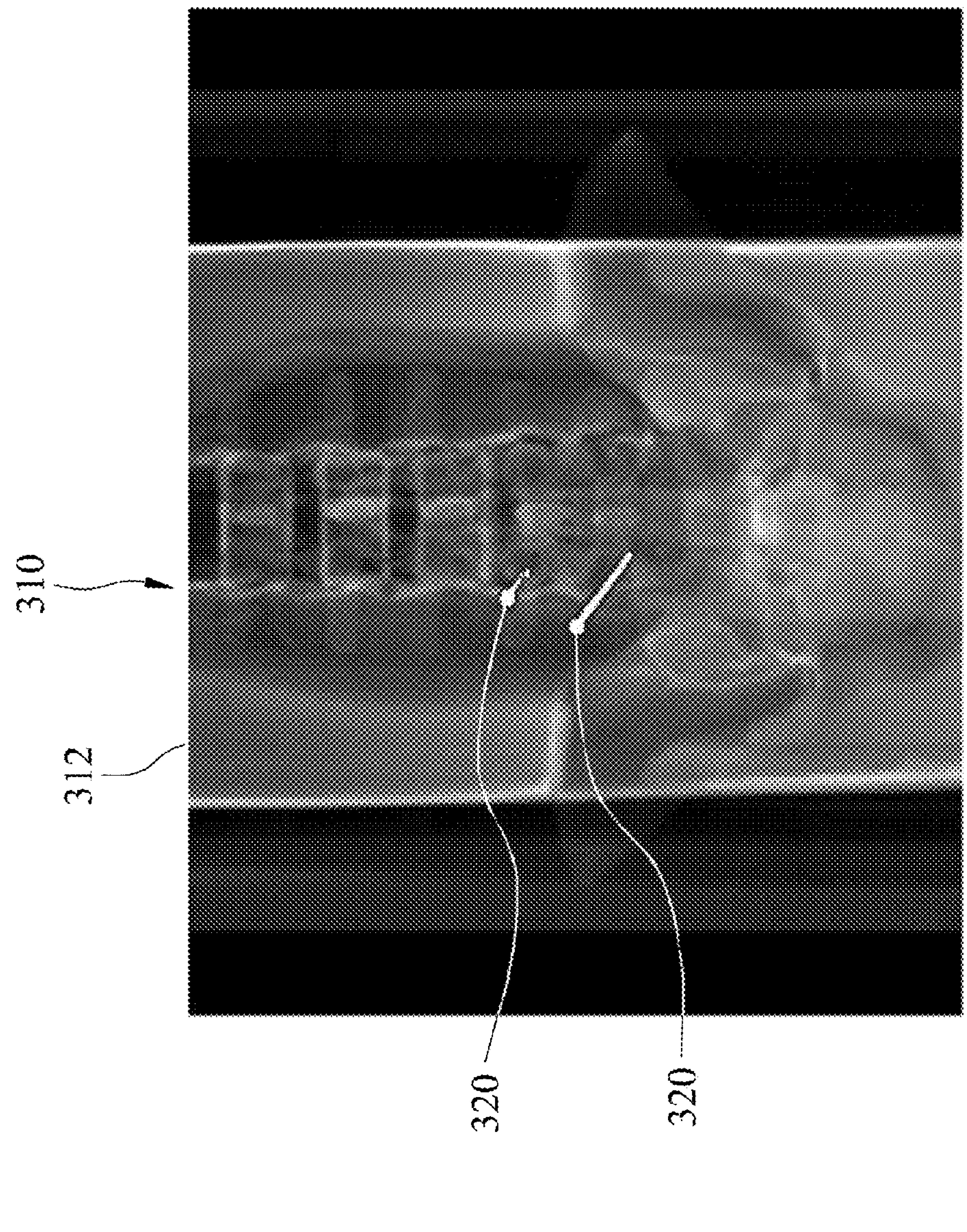

Fig. 3A

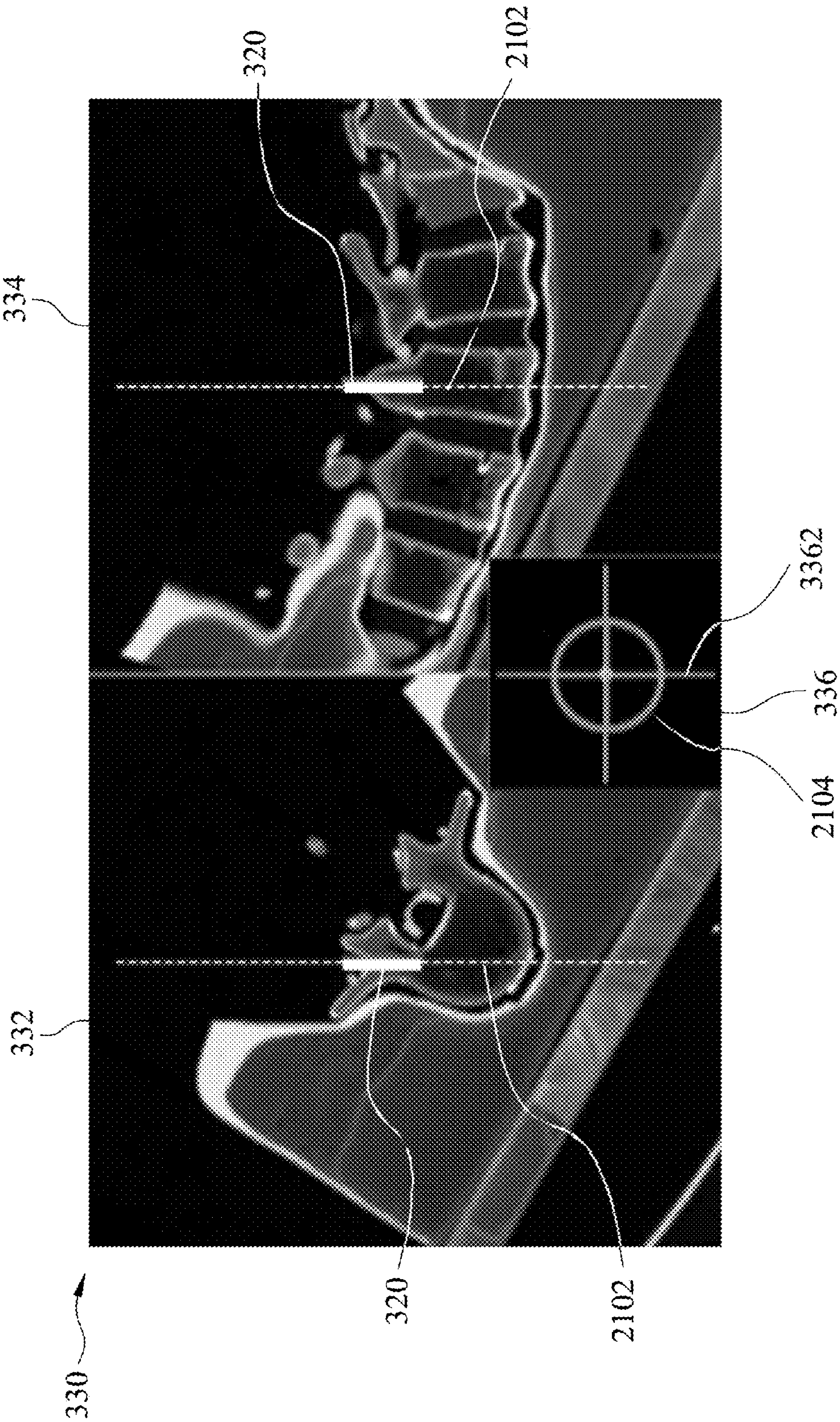

Fig. 3B

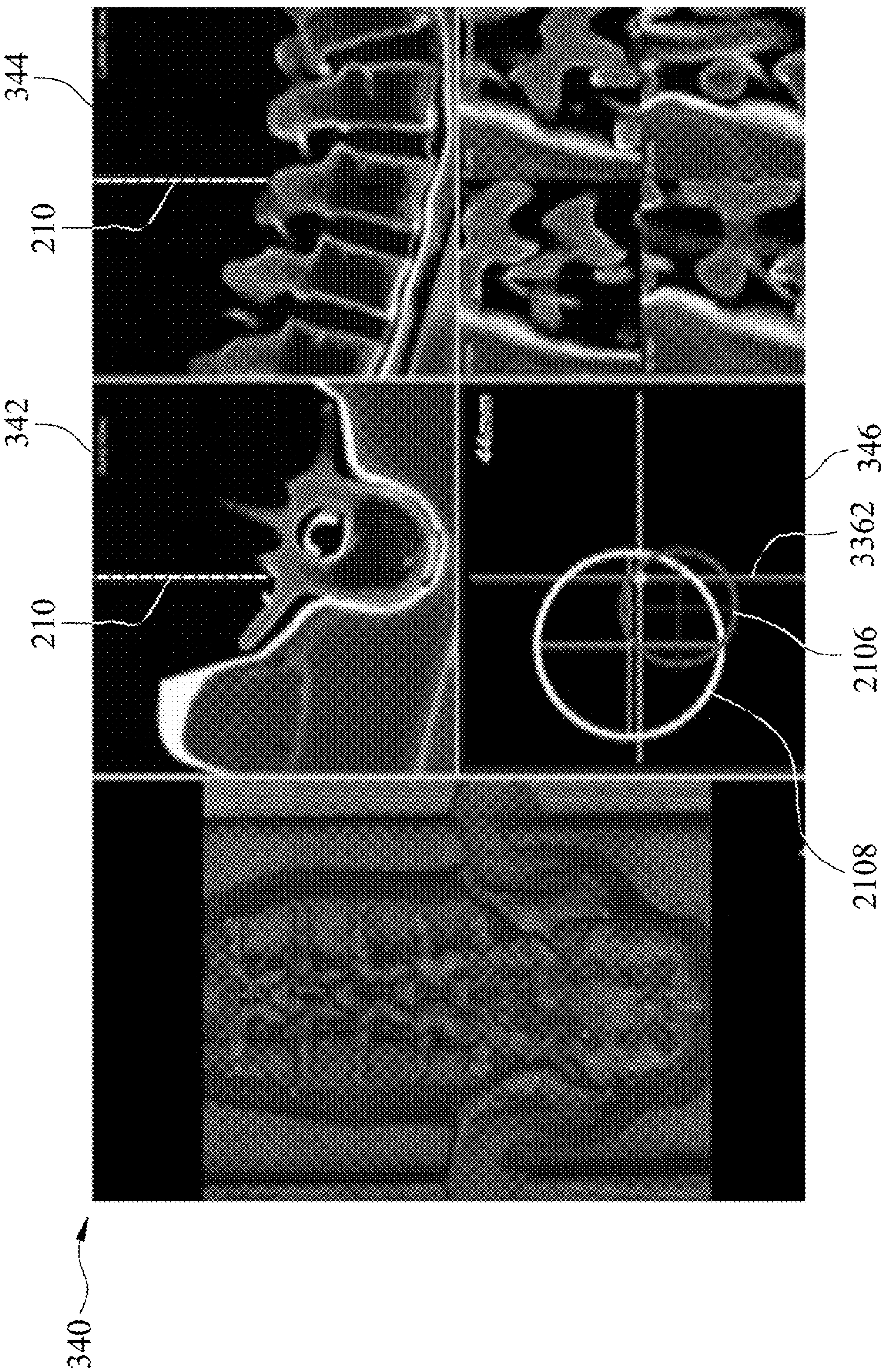

Fig. 3C

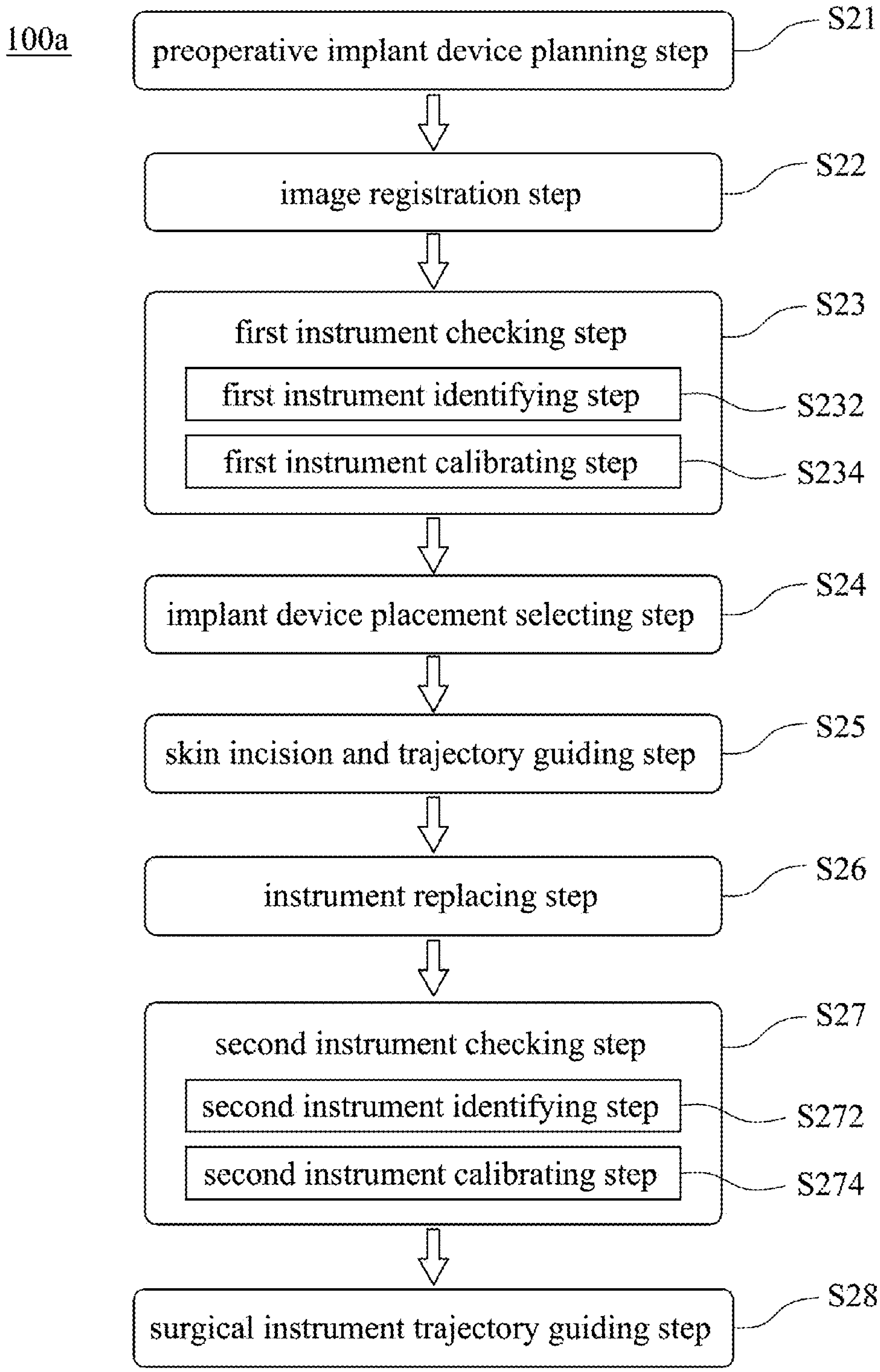
100a
preoperative implant device planning step
S21
image registration step
S22
first instrument checking step
S23
first instrument identifying step
S232
first instrument calibrating step
S234
implant device placement selecting step
S24
skin incision and trajectory guiding step
S25
instrument replacing step
S26
second instrument checking step
S27
second instrument identifying step
S272
second instrument calibrating step
S274
surgical instrument trajectory guiding step
S28

Fig. 4

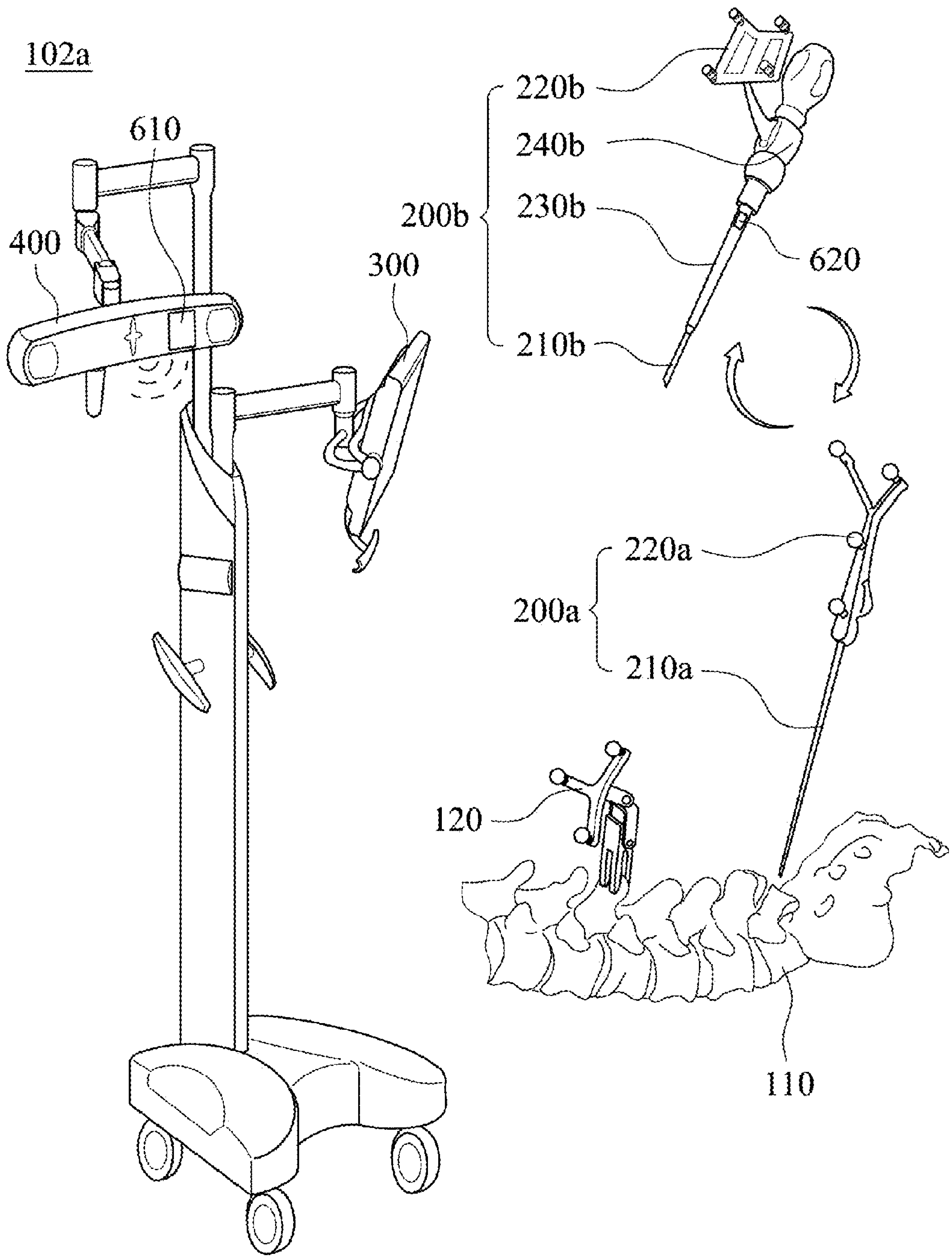
102a
610
400
300
220b
240b
200b
230b
620
210b
220a
200a
210a
120
110

Fig. 5A

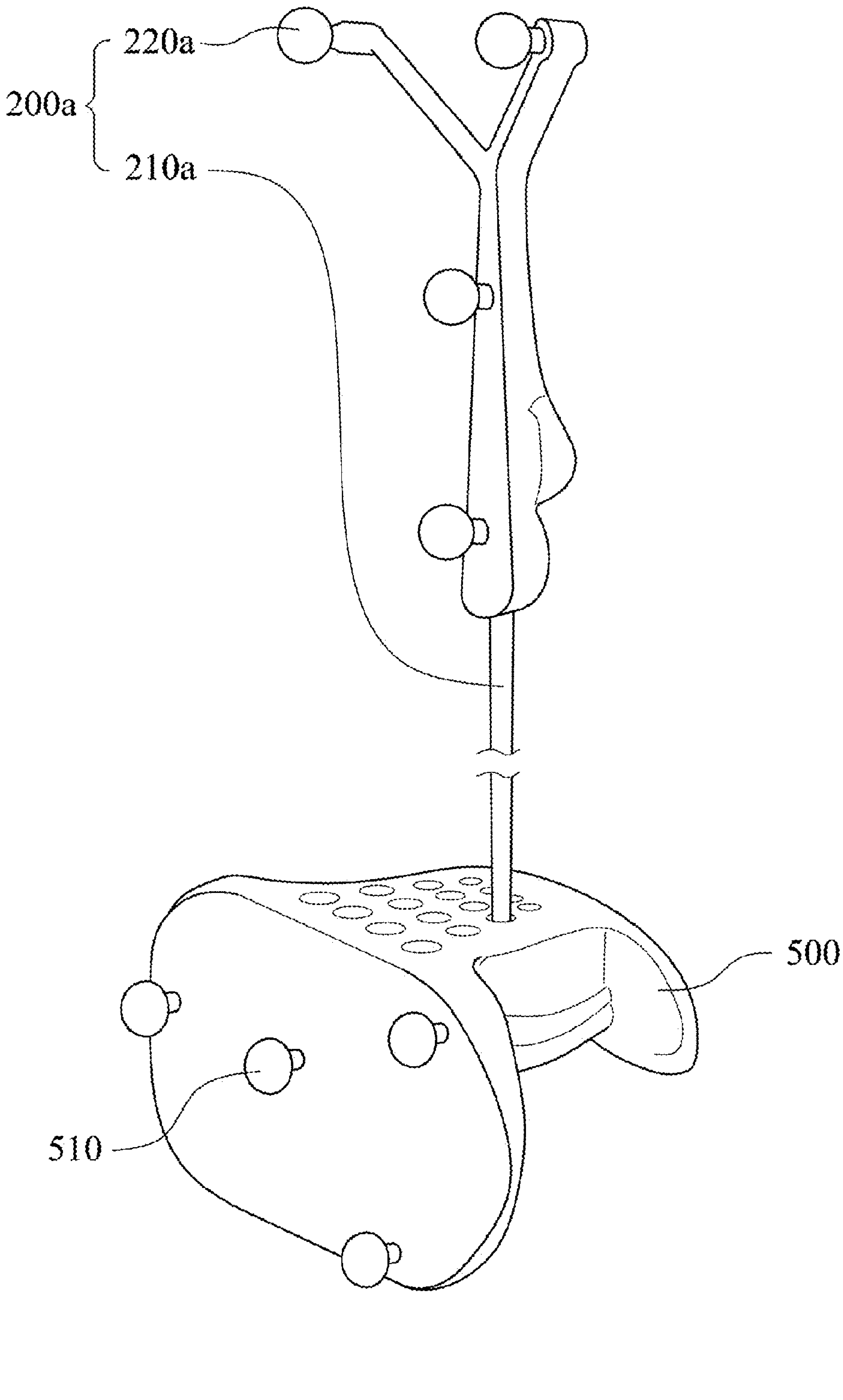

Fig. 5B

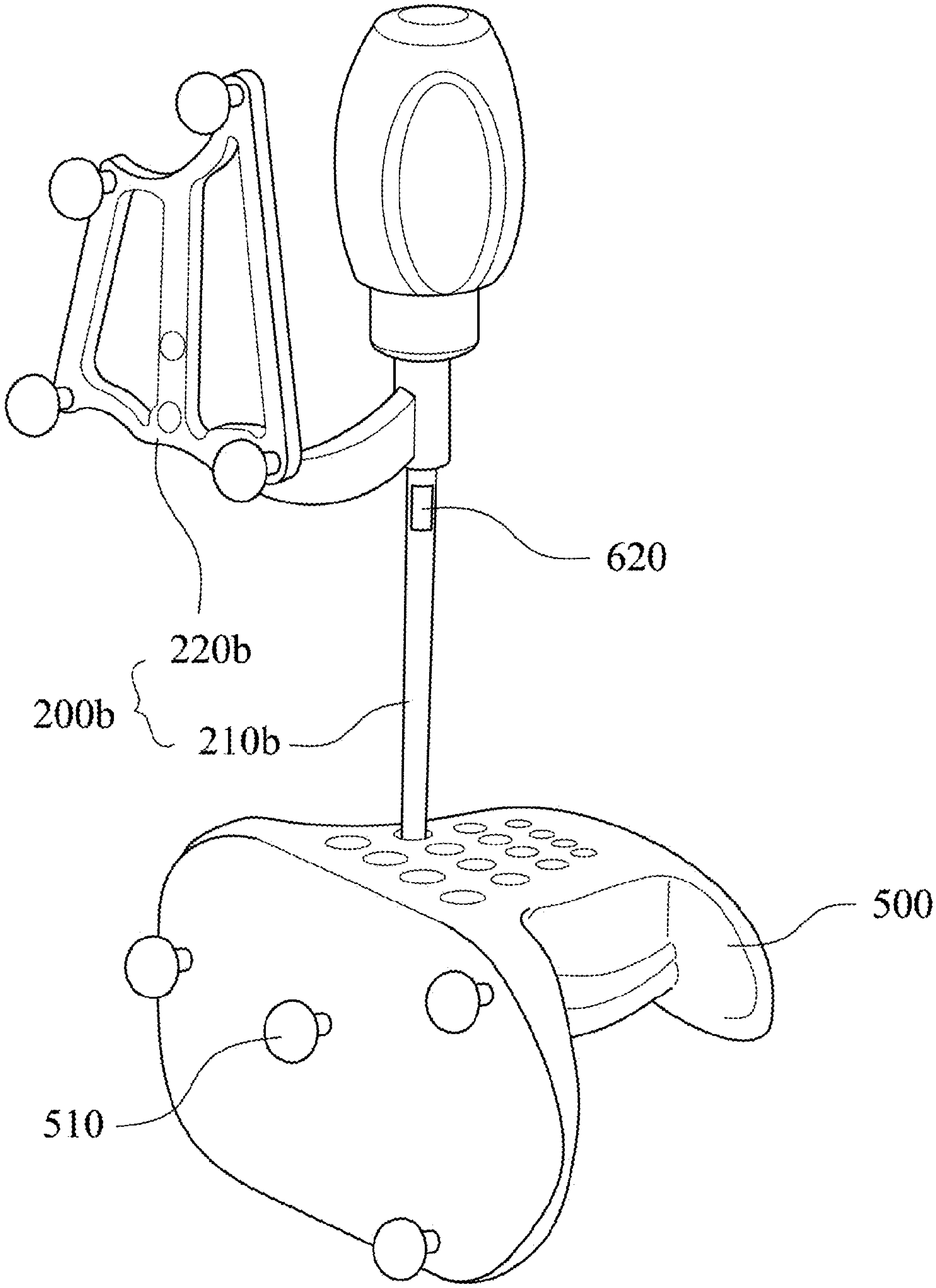

Fig. 5C

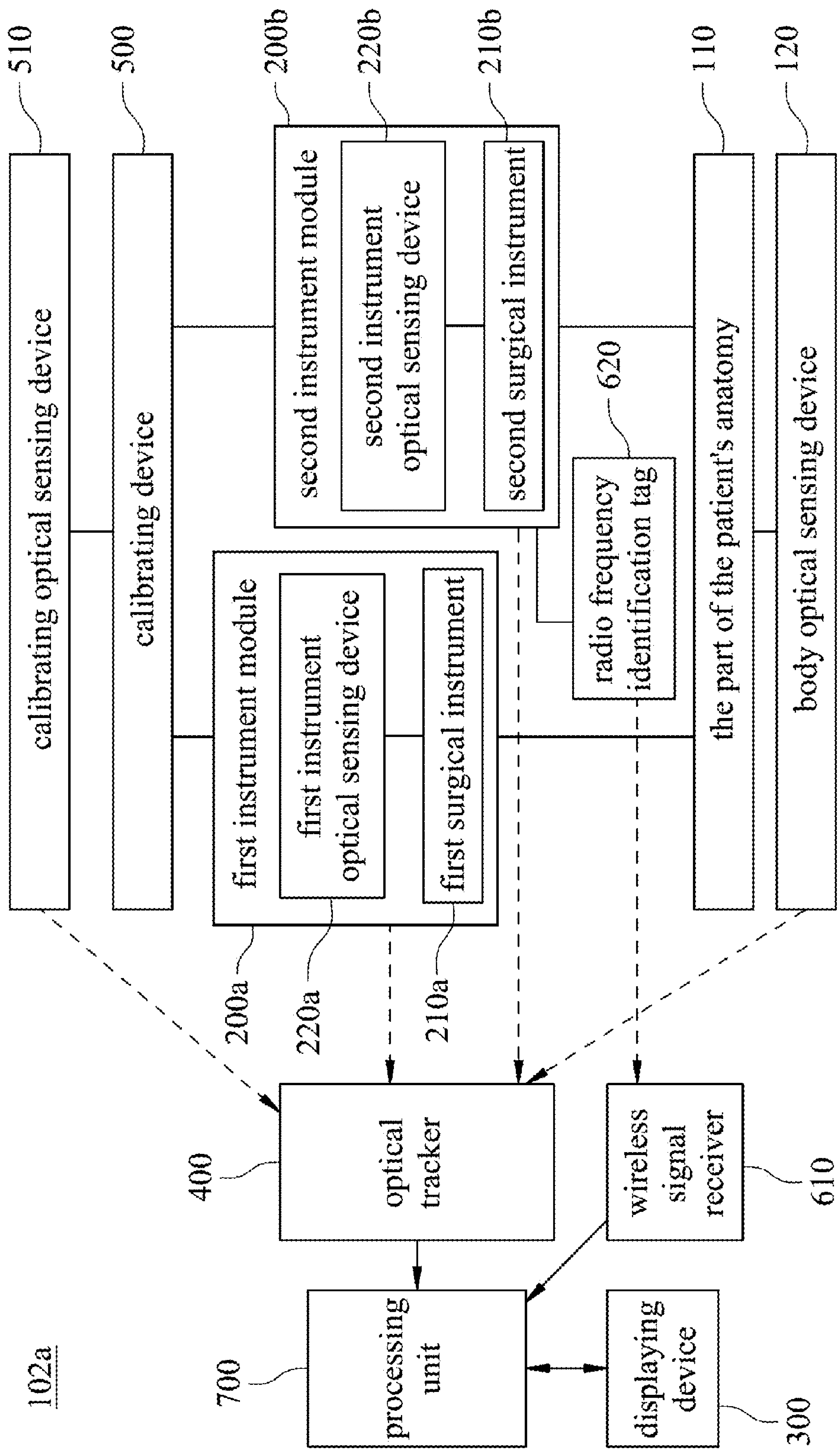
102a
510
calibrating optical sensing device
500
calibrating device
200b
second instrument module
220b
second instrument optical sensing device
210b
second surgical instrument
620
radio frequency identification tag
110
the part of the patient's anatomy
120
body optical sensing device
200a
first instrument module
220a
first instrument optical sensing device
210a
first surgical instrument
400
optical tracker
610
wireless signal receiver
700
processing unit
300
displaying device

Fig. 5D

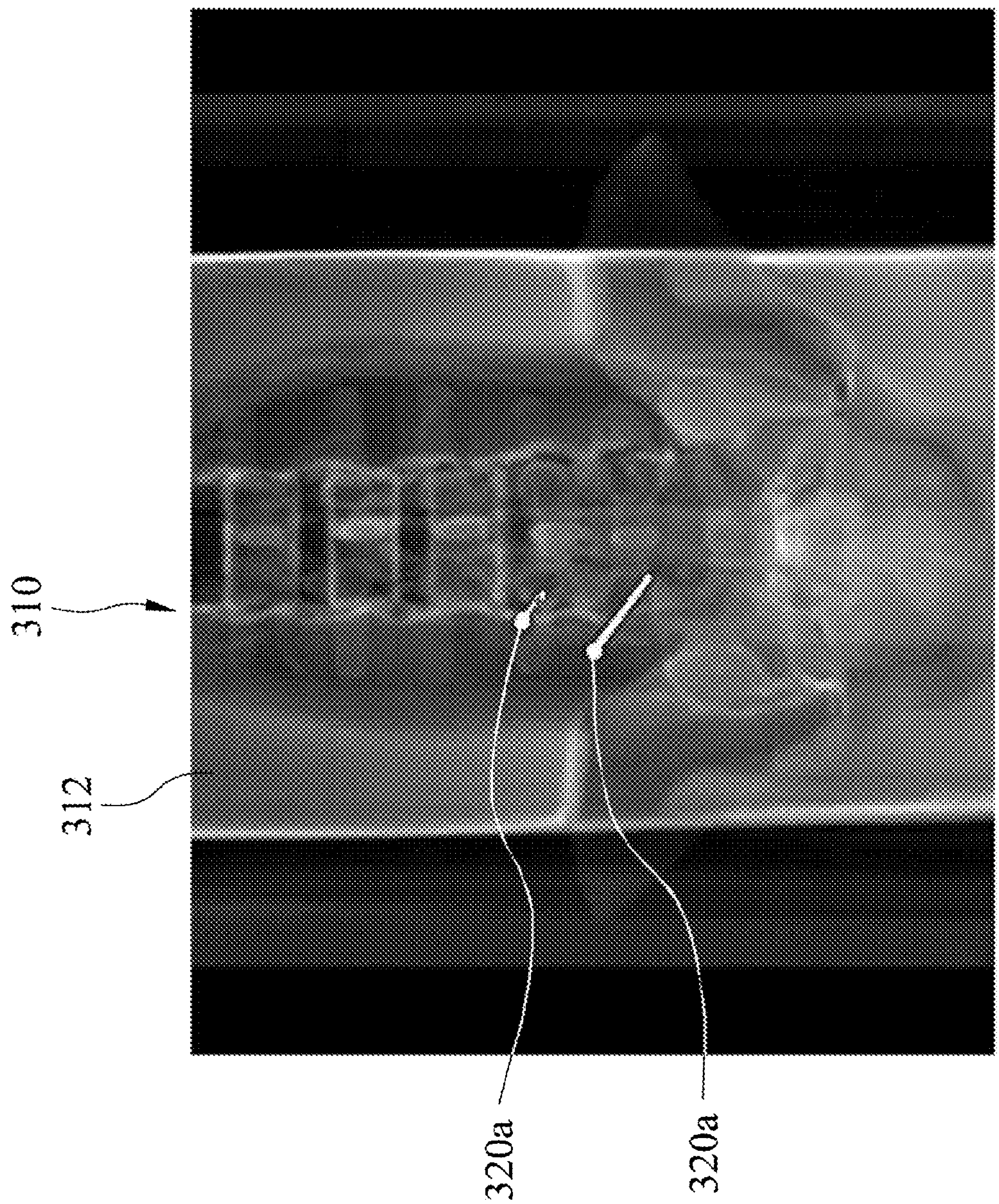

Fig. 6A

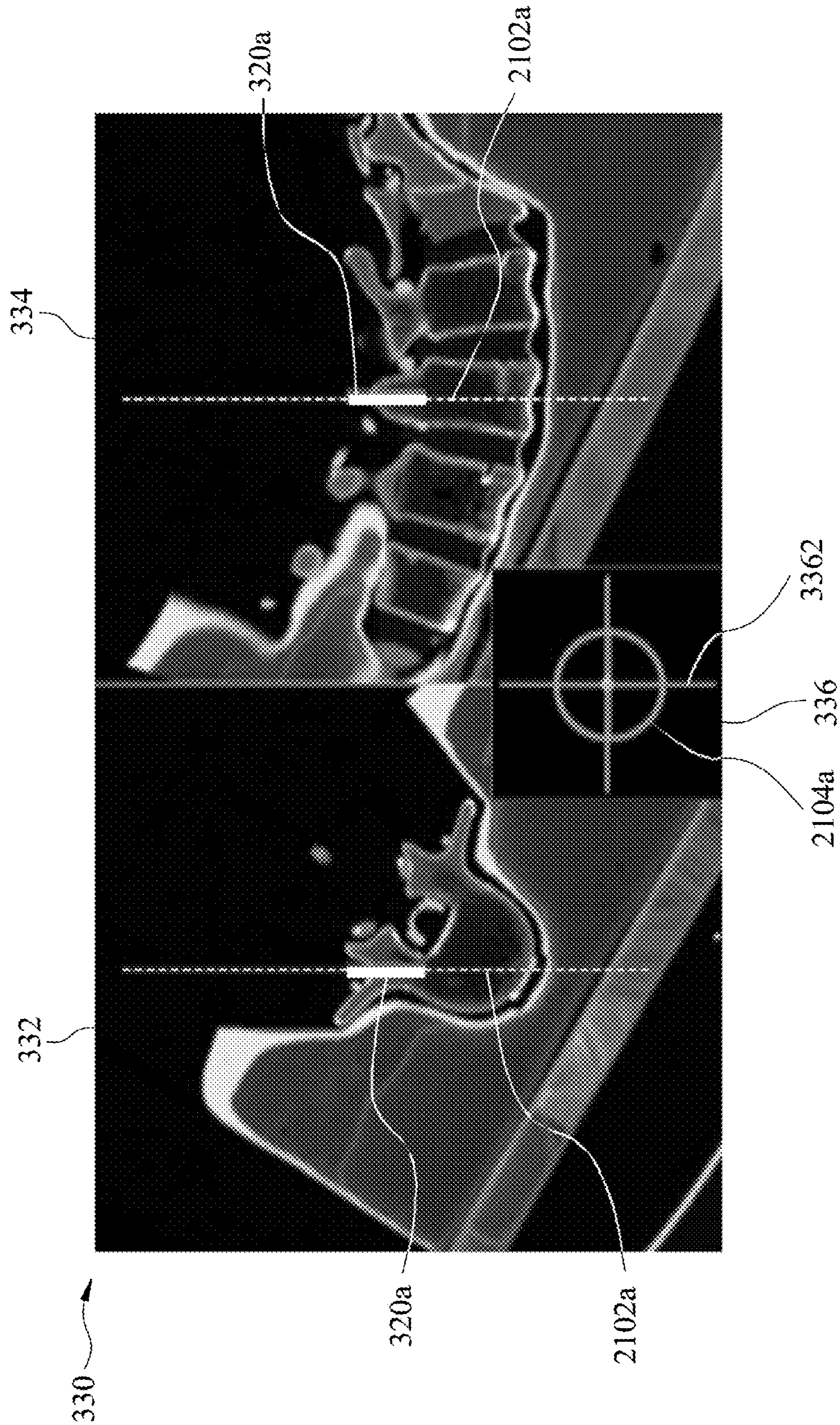

Fig. 6B

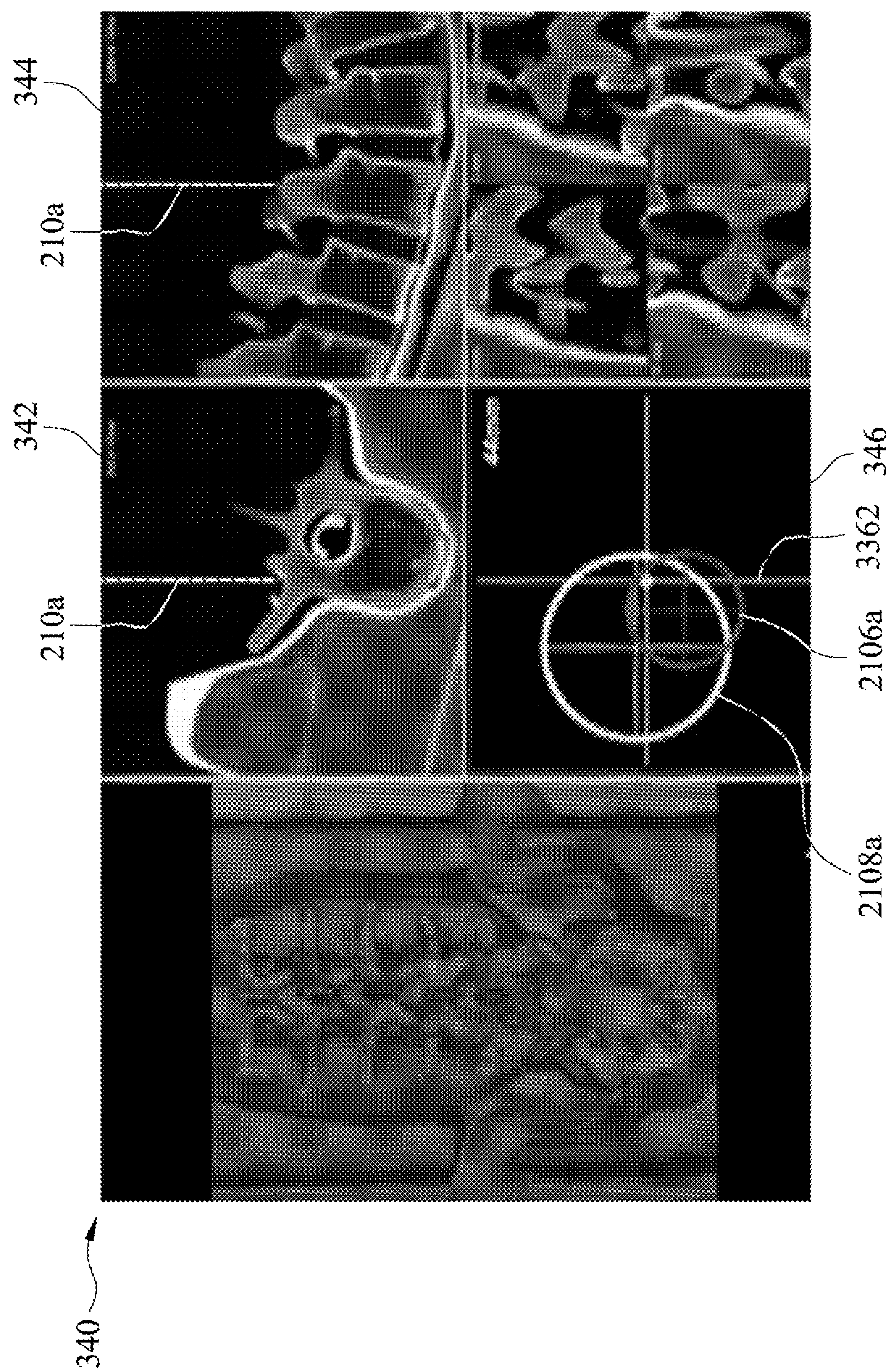

Fig. 6C

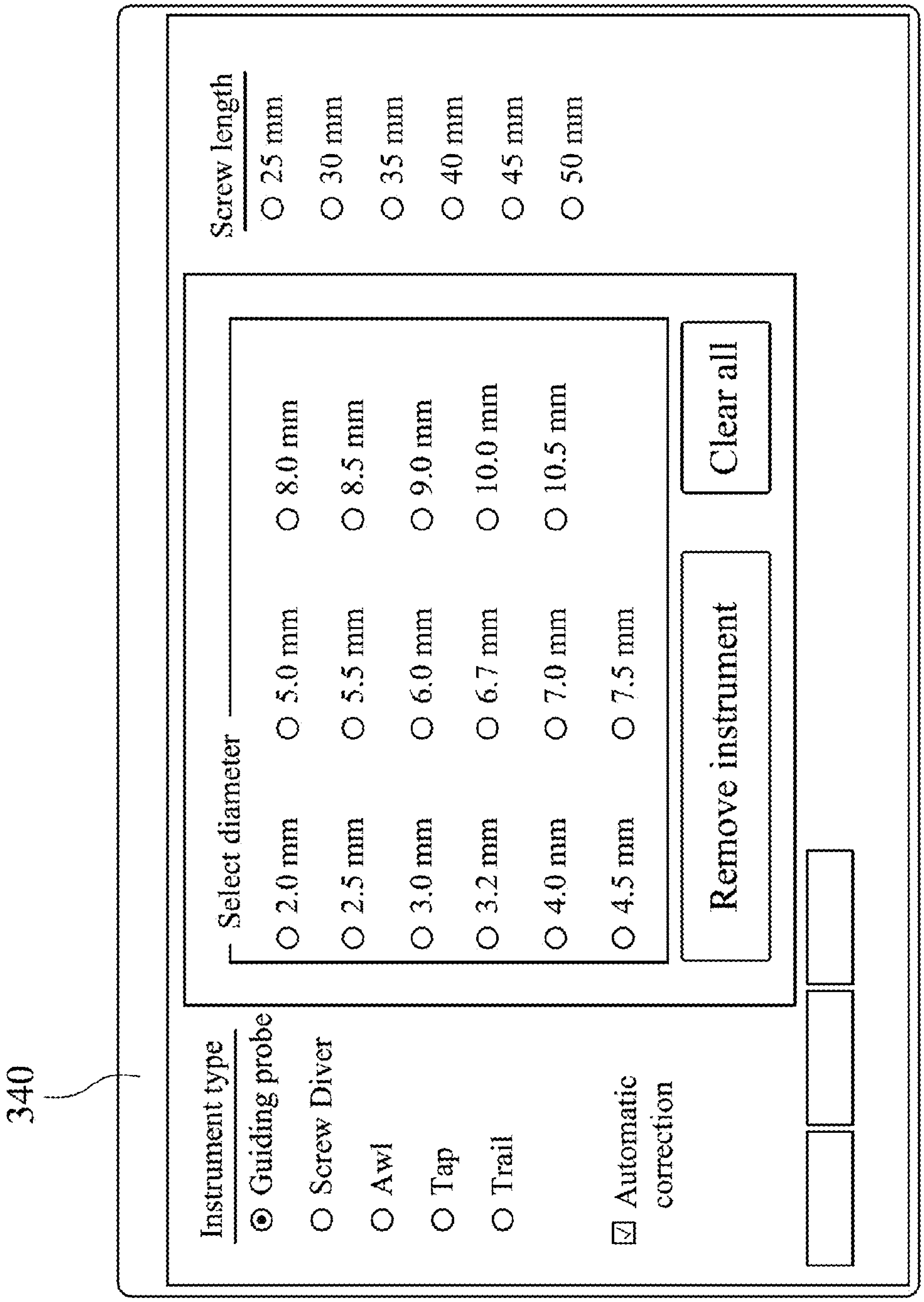
340
Instrument type
Guiding probe
Screw Diver
Awl
Tap
Trail
Automatic correction
Select diameter
2.0 mm
2.5 mm
3.0 mm
3.2 mm
4.0 mm
4.5 mm
5.0 mm
5.5 mm
6.0 mm
6.7 mm
7.0 mm
7.5 mm
8.0 mm
8.5 mm
9.0 mm
10.0 mm
10.5 mm
Remove instrument
Clear all
Screw length
25 mm
30 mm
35 mm
40 mm
45 mm
50 mm

Fig. 6D

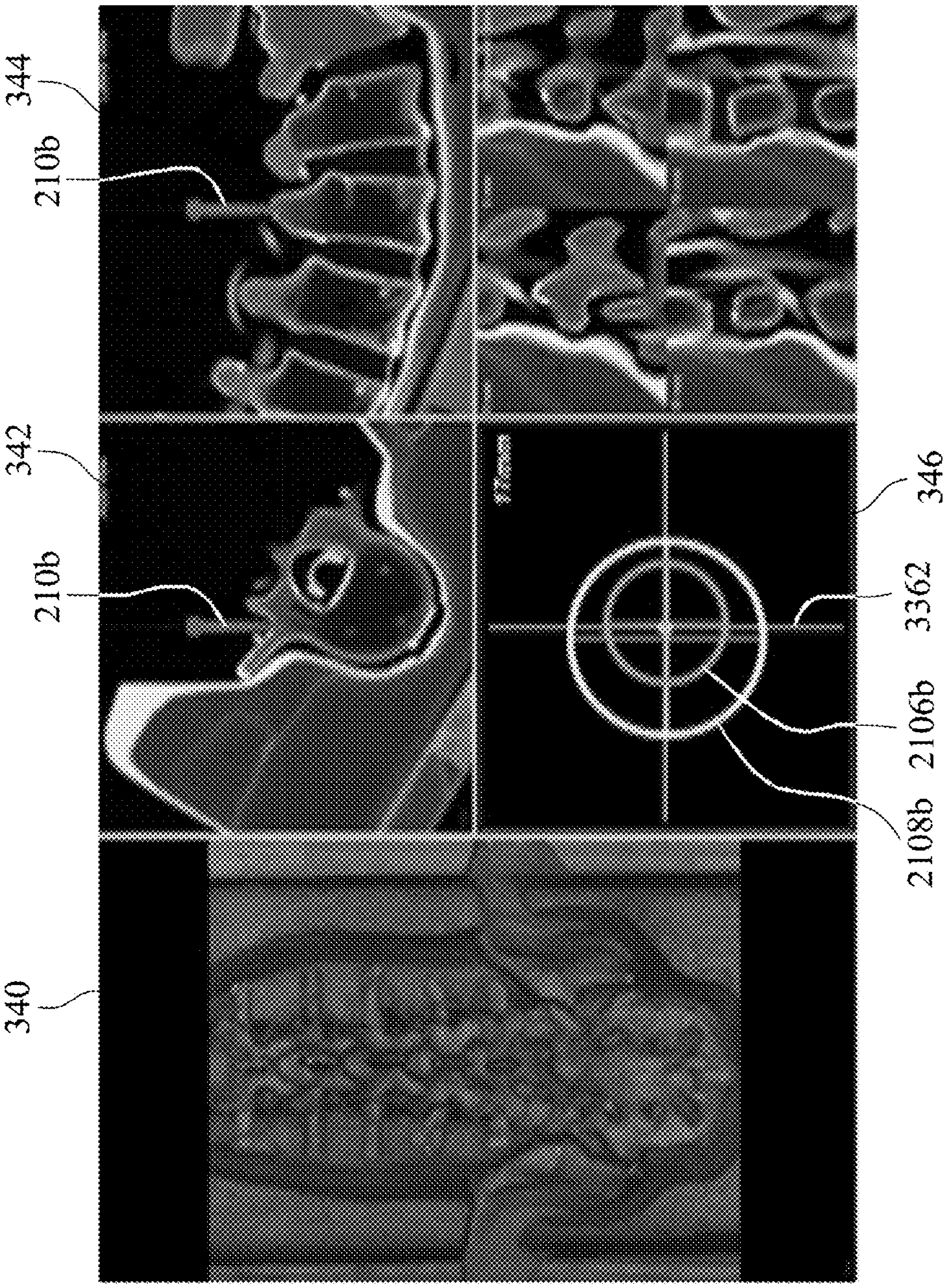

Fig. 6E

NO-TOUCH SURGICAL NAVIGATION METHOD AND SYSTEM THEREOF

RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application Ser. No. 62/421,995 filed Nov. 14, 2016, and China application No. 201710630485.6 filed on Jul. 28, 2017, the disclosures of which are incorporated herein by reference in their entireties.

BACKGROUND

Technical Field

The present disclosure relates to a surgical navigation method and a surgical navigation system thereof. More particularly, the present disclosure relates to a no-touch surgical navigation method and a no-touch surgical navigation system thereof.

Description of Related Art

Surgical navigation systems, also known as computer assisted surgery and image guided surgery, aid surgeons (i.e., physicians) in locating patient anatomical structures, guiding surgical instruments (such as a bone screw), and implanting medical devices with a high degree of accuracy. A conventional surgical navigation system typically includes a processing unit, a tracking device, and patient anatomical information. The patient anatomical information can be obtained by using a 2D/3D imaging mode such a fluoroscopy, computer tomography (CT), a C-arm X-ray machine or by simply defining the location of patient anatomy with the surgical navigation system. Surgical navigation systems can be used for a wide variety of surgeries to improve patient outcomes.

Conventional surgical navigation systems generally include a touch screen for selecting information and controlling surgical operations via an operator action. In one surgical procedure, the physician needs to alternatively operate surgical instruments and the conventional surgical navigation system. In another surgical procedure, the physician and the operator operate surgical instruments and the conventional surgical navigation system, respectively. No matter what procedure is employed, the conventional surgical navigation system requires an additional human support to control redundant touch and increases surgical procedural complexity, thereby increasing failure risk caused by a human error. In particular, when the surgical instrument is replaced, the accuracy, reliability and safety of the system will be significantly decreased. Therefore, a surgical navigation system and a surgical navigation method having the features of no redundant touch, high safety, high accuracy, high precision and convenient operation are commercially desirable. A no-touch surgical navigation system and a no-touch surgical navigation method of the present disclosure are proposed to overcome the conventional problems.

SUMMARY

According to one aspect of the present disclosure, a no-touch surgical navigation method for guiding a surgical instrument corresponding to a part of a patient's anatomy provides a preoperative implant device planning step, an image registration step, an instrument checking step, an implant device placement selecting step and a skin incision and trajectory guiding step. The preoperative implant device

planning step is for acquiring at least one preoperative implant device planning image and visualizing the preoperative implant device planning image on a displaying device. The image registration step is for establishing a spatial coordinate transformation relationship between the part of the patient's anatomy and the preoperative implant device planning image, and matching the preoperative implant device planning image and the part of the patient's anatomy via the spatial coordinate transformation relationship. The instrument checking step is for identifying the surgical instrument, and then calibrating a size of the surgical instrument to display an instrument tip mark of the surgical instrument on the displaying device. The implant device placement selecting step is for moving the surgical instrument by a user, and the instrument tip mark is synchronously moved with the surgical instrument to select a virtual surgical instrument pattern in the preoperative implant device planning image, and then a skin incision and trajectory guiding picture is shown on the displaying device. The skin incision and trajectory guiding step is for moving the surgical instrument by the user according to the skin incision and trajectory guiding picture so as to move the instrument tip mark close to a planned surgical position, and the planned surgical position is displayed in the skin incision and trajectory guiding picture.

According to another aspect of the present disclosure, a no-touch surgical navigation method for guiding a plurality of surgical instruments corresponding to a part of the patient's anatomy provides a preoperative implant device planning step, an image registration step, a first instrument checking step, an implant device placement selecting step, a skin incision and trajectory guiding step, an instrument replacing step, a second instrument checking step and a surgical instrument trajectory guiding step. The surgical instruments include a first surgical instrument and a second surgical instrument. The preoperative implant device planning step is for acquiring at least one preoperative implant device planning image and visualizing the preoperative implant device planning image on a displaying device. The image registration step is for establishing a spatial coordinate transformation relationship between the part of the patient's anatomy and the preoperative implant device planning image, and matching the preoperative implant device planning image and the part of the patient's anatomy via the spatial coordinate transformation relationship. The first instrument checking step is for identifying the first surgical instrument, and then calibrating a size of the first surgical instrument to display a first instrument tip mark of the first surgical instrument on the displaying device. The implant device placement selecting step is for moving the first surgical instrument by a user, and the first instrument tip mark is synchronously moved with the first surgical instrument to select a virtual second surgical instrument pattern in the preoperative implant device planning image. Then, a skin incision and trajectory guiding picture is shown on the displaying device. The skin incision and trajectory guiding step is for moving the first surgical instrument by the user according to the skin incision and trajectory guiding picture so as to move the first instrument tip mark close to a planned surgical position. The planned surgical position is displayed in the skin incision and trajectory guiding picture. When the first instrument tip mark is aligned with the planned surgical position, the skin incision and trajectory guiding picture is changed to a surgical instrument guiding picture on the displaying device. The instrument replacing step is for replacing the first surgical instrument with the second surgical instrument by the user. The second instrument checking step is for identifying the second surgical instrument, and then calibrating a size of the second surgical instrument to display a second instrument tip mark of the second surgical instrument on the displaying device. The surgical instrument trajectory guiding step is for moving the second surgical instrument close to the planned surgical position according to the surgical instrument guiding picture.

According to further another aspect of the present disclosure, a no-touch surgical navigation system using the no-touch surgical navigation method includes a surgical instrument, a displaying device, an optical tracker and a processing unit. The surgical instrument moved by the user and connected to an instrument optical sensing device. The displaying device includes a screen which displays a preoperative implant device planning image, a skin incision and trajectory guiding picture or a surgical instrument guiding picture. The optical tracker is configured to sense the instrument optical sensing device. The instrument optical sensing device is oriented towards the optical tracker so as to identify the surgical instrument by the optical tracker and obtain a surgical instrument datum corresponding to the surgical instrument. The processing unit is signally connected to the displaying device and the optical tracker. The processing unit includes a preoperative implant device planning module, an image registration module, an instrument checking module, an implant device placement selecting module and a trajectory guiding module. The preoperative implant device planning module is configured to acquire the preoperative implant device planning image and visualize the preoperative implant device planning image on the screen. The image registration module is signally connected to the preoperative implant device planning module. The image registration module is configured to establish the spatial coordinate transformation relationship between the part of the patient's anatomy and the preoperative implant device planning image, and match the preoperative implant device planning image and the part of the patient's anatomy via the spatial coordinate transformation relationship. The instrument checking module is signally connected to the image registration module and the screen. The instrument checking module is configured to receive the surgical instrument datum and identify a position of the surgical instrument on the screen, and then calibrate the size of the surgical instrument to display the instrument tip mark of the surgical instrument on the screen. The implant device placement selecting module is signally connected to the instrument checking module and the image registration module. The implant device placement selecting module is configured to select a virtual surgical instrument pattern in the preoperative implant device planning image by moving the instrument tip mark of the surgical instrument so as to display the skin incision and trajectory guiding picture on the screen. The trajectory guiding module is signally connected to the instrument checking module and the implant device placement selecting module. The trajectory guiding module is configured to move the instrument tip mark close to a planned surgical position by moving the surgical instrument according to the skin incision and trajectory guiding picture on the screen.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure can be more fully understood by reading the following detailed description of the embodiment, with reference made to the accompanying drawings as follows:

FIG. **1** shows a flow chart of a no-touch surgical navigation method for guiding a surgical instrument corresponding to a part of a patient's anatomy according to a first embodiment of the present disclosure;

FIG. **2**A shows a schematic view of a no-touch surgical navigation system for guiding the surgical instrument corresponding to the part of the patient's anatomy according to the first embodiment of the present disclosure;

FIG. **2**B shows a schematic view of the surgical instrument cooperated with a calibrating device according to the first embodiment of the present disclosure;

FIG. **2**C shows a block diagram of the no-touch surgical navigation system according to the first embodiment of the present disclosure;

FIG. **3**A shows a schematic view of a preoperative implant device planning image on a displaying device according to the first embodiment of the present disclosure;

FIG. **3**B shows a schematic view of a skin incision and trajectory guiding picture on the displaying device according to the first embodiment of the present disclosure;

FIG. **3**C shows a schematic view of a surgical instrument guiding picture on the displaying device according to the first embodiment of the present disclosure;

FIG. **4** shows a flow chart of a no-touch surgical navigation method for guiding a plurality of surgical instruments corresponding to a part of a patient's anatomy according to a second embodiment of the present disclosure;

FIG. **5**A shows a schematic view of a no-touch surgical navigation system for guiding the surgical instruments corresponding to the part of the patient's anatomy according to the second embodiment of the present disclosure;

FIG. **5**B shows a schematic view of a first surgical instrument cooperated with a calibrating device according to the second embodiment of the present disclosure;

FIG. **5**C shows a schematic view of a second surgical instrument cooperated with the calibrating device according to the second embodiment of the present disclosure;

FIG. **5**D shows a block diagram of the no-touch surgical navigation system according to the second embodiment of the present disclosure;

FIG. **6**A shows a schematic view of a preoperative implant device planning image on a displaying device according to the second embodiment of the present disclosure;

FIG. **6**B shows a schematic view of a skin incision and trajectory guiding picture on the displaying device according to the second embodiment of the present disclosure;

FIG. **6**C shows a schematic view of a surgical instrument guiding picture on the displaying device for guiding the first surgical instrument according to the second embodiment of the present disclosure;

FIG. **6**D shows a schematic view of the surgical instrument guiding picture on the displaying device for checking the second surgical instrument according to the second embodiment of the present disclosure; and

FIG. **6**E shows a schematic view of the surgical instrument guiding picture on the displaying device for guiding the second surgical instrument according to the second embodiment of the present disclosure.

DETAILED DESCRIPTION

FIG. **1** shows a flow chart of a no-touch surgical navigation method **100** for guiding a surgical instrument **210** corresponding to a part of a patient's anatomy **110** according to a first embodiment of the present disclosure; FIG. **2**A shows a schematic view of a no-touch surgical navigation system **102** for guiding the surgical instrument **210** corresponding to the part of the patient's anatomy **110** according to the first embodiment of the present disclosure; FIG. **2**B shows a schematic view of the surgical instrument **210** cooperated with a calibrating device **500** according to the first embodiment of the present disclosure; FIG. **2**C shows a block diagram of the no-touch surgical navigation system **102** according to the first embodiment of the present disclosure; FIG. **3**A shows a schematic view of a preoperative implant device planning image **310** on a displaying device **300** according to the first embodiment of the present disclosure; FIG. **3**B shows a schematic view of a skin incision and trajectory guiding picture **330** on the displaying device **300** according to the first embodiment of the present disclosure; and FIG. **3**C shows a schematic view of a surgical instrument guiding picture **340** on the displaying device **300** according to the first embodiment of the present disclosure. The no-touch surgical navigation method **100** is utilized for guiding the surgical instrument **210** corresponding to the part of the patient's anatomy **110**. The surgical instrument **210** may be a guiding probe or a bone screw, and the part of the patient's anatomy **110** may be a vertebral body. The no-touch surgical navigation method **100** provides a preoperative implant device planning step S**11**, an image registration step S**12**, an instrument checking step S**13**, an implant device placement selecting step S**14**, a skin incision and trajectory guiding step S**15** and a surgical instrument trajectory guiding step S**16**.

The preoperative implant device planning step S**11** is for acquiring at least one preoperative implant device planning image **310** and visualizing the preoperative implant device planning image **310** on the displaying device **300**, as shown in FIG. **3**A. In detail, the preoperative implant device planning image **310** includes a preoperative patient anatomical image **312** and a virtual surgical instrument pattern **320**. In the case of spinal surgery, the preoperative patient anatomical image **312** is a three-dimensional medical image of the vertebral body of the patient which is reconstructed after the part of the patient's anatomy **110** scanned by a computed tomography (CT) scan. The virtual surgical instrument pattern **320** is a bone screw pattern. After the preoperative patient anatomical image **312** obtain by the CT scan, the user can plan the specification and placement of an implant device (i.e., the surgical instrument **210**) according to the preoperative patient anatomical image **312**. The specification of the implant device includes the diameter and the length of the surgical instrument **210**. The placement of the implant device includes a correct position and a panoramic image of the surgical instrument **210**. The specification and placement of the surgical instrument **210** can be stored for reading and reusing. In addition, the preoperative implant device planning step S**11** is used for verifying a panoramic image of the surgical instrument **210** (i.e., the implant device) and checking a relative position between the virtual surgical instrument pattern **320** and the preoperative patient anatomical image **312**. The preoperative implant device planning step S**11** provides a pre-planning interface displaying step, an implant trajectory pattern adding step, an implant trajectory pattern adjusting step and a panoramic image verifying step. The pre-planning interface displaying step is for displaying the preoperative patient anatomical image **312**, a menu and a cursor on a screen of the displaying device **300**. The implant trajectory pattern adding step is for moving the cursor to select an implant adding item of the menu by a user and then generating the virtual surgical instrument pattern **320** in the preoperative patient anatomical image **312**, and the virtual surgical instrument pattern **320** is located at a starting position. The implant trajectory pattern adjusting step is for controlling the cursor to adjust a position of the virtual surgical instrument pattern **320** and then moving the virtual surgical instrument pattern **320** from the starting position to a target position in the preoperative patient anatomical image **312**. The panoramic image verifying step is for rotating the preoperative patient anatomical image **312** around the virtual surgical instrument pattern **320** at a viewing angle according to the target position and the virtual surgical instrument pattern **320** as a central axis, and the viewing angle is greater than 0 degrees and smaller than or equal to 180 degrees. When the viewing angle is sequentially changed from 0 degrees to 180 degrees, a first semicircular region surrounding the surgical instrument **210** (0-180 degrees) can be verified by the user, and a second semicircular region surrounding the surgical instrument **210** (180-360 degrees) is reversely symmetrical to the first semicircular region surrounding the surgical instrument **210** (0-180 degrees). Certainly, the viewing angle may be greater than 180 degrees and smaller than or equal to 360 degrees according to the user's needs. In other words, the viewing angle can be sequentially changed from 0 degrees to 360 degrees in order to completely verify panoramic images of the surgical instrument **210**. Accordingly, the preoperative implant device planning step S**11** of the present disclosure utilizes the 180-degree rotation of the preoperative patient anatomical image **312** around the virtual surgical instrument pattern **320** as the central axis to allow the physician to correctly verify the relative positions of the bone screw (corresponding to the virtual surgical instrument pattern **320**) and the vertebral body (corresponding to the preoperative patient anatomical image **312**), thereby adaptively correcting the planning path and positions of the surgical instrument **210** to improve the safety and reliability before surgical procedures.

The image registration step S**12** is for establishing a spatial coordinate transformation relationship between the part of the patient's anatomy **110** and the preoperative implant device planning image **310**, and matching the preoperative implant device planning image **310** and the part of the patient's anatomy **110** via the spatial coordinate transformation relationship. In detail, the image registration step S**12** is for building the links between the part of the patient's anatomy **110** and the preoperative implant device planning image **310**. The image registration step S**12** is for driving a radiographic image capturing system to capture an intraoperative patient anatomical image corresponding to the part of the patient's anatomy **110** and disposing a radiographic optical sensing device on the radiographic image capturing system. A body optical sensing device **120** is disposed on the part of the patient's anatomy **110**. In one embodiment, the radiographic image capturing system is a C-arm X-ray machine, and the body optical sensing device **120** includes a plurality of reflective balls and a dynamic reference frame (DRF) connected to the reflective balls. Then, the radiographic optical sensing device and the body optical sensing device **120** are both oriented towards an optical tracker **400** to establish the spatial coordinate transformation relationship between the part of the patient's anatomy **110** and the preoperative implant device planning image **310**. The preoperative patient anatomical image **312** is corresponding to the intraoperative patient anatomical image via the spatial coordinate transformation relationship. In other words, the physician takes two or more C-arm pictures via the C-arm X-ray machine to obtain the actual spatial coordinates of the patient during the surgical procedure. Then, the preoperative patient anatomical image **312** of the preoperative implant device planning image **310** is matched with the C-arm pictures through an image registration algorithm of the system, so that the spatial coordinate of the C-arm pictures is consistent with the spatial coordinate of the patient.

The instrument checking step S**13** is for identifying the surgical instrument **210**, and then calibrating a size of the surgical instrument **210** to display an instrument tip mark (not shown) of the surgical instrument **210** on the displaying device **300**. In detail, an instrument module **200** includes the surgical instrument **210** and an instrument optical sensing device **220**, as shown in FIG. **2**A. The surgical instrument **210** is a guiding probe. The instrument optical sensing device **220** includes four reflective balls and a Y-shaped dynamic reference frame. Moreover, the instrument checking step S**13** includes an instrument identifying step S**132** and an instrument calibrating step S**134**. The instrument identifying step S**132** is for disposing the instrument optical sensing device **220** on the surgical instrument **210**, and the instrument optical sensing device **220** is oriented towards the optical tracker **400** so as to identify the type and specification of the surgical instrument **210** by the optical tracker **400**. The instrument calibrating step S**134** is for disposing a calibrating optical sensing device **510** on the calibrating device **500**, and then engaging the surgical instrument **210** with the calibrating device **500**, and orienting the surgical instrument **210** and the calibrating device **500** towards the optical tracker **400**. The surgical instrument **210** of the instrument module **200** and the calibrating device **500** are simultaneously identified by the optical tracker **400** to establish a spatial coordinate transformation relationship between a tip of the surgical instrument **210** and the instrument optical sensing device **220**. In other words, the optical tracker **400** simultaneously detects the four reflective balls of the instrument optical sensing device **220** and the four reflective balls of the calibrating optical sensing device **510** of the calibrating device **500** to obtain a precise position of the tip of the surgical instrument **210** in space by the eight reflective balls of the instrument optical sensing device **220** and the calibrating device **500**. The precise position of the tip of the surgical instrument **210** is presented on the displaying device **300**, as shown in FIG. **2**B.

The implant device placement selecting step S**14** is for moving the surgical instrument **210** by the user, and the instrument tip mark is synchronously moved with the surgical instrument **210** to select a virtual surgical instrument pattern **320** in the preoperative implant device planning image **310**. Then, a skin incision and trajectory guiding picture **330** is shown on the displaying device **300**, as shown in FIG. **3**A. In detail, the implant device placement selecting step S**14** is for moving the surgical instrument **210** by the user to move the instrument tip mark corresponding to a position of the tip of the surgical instrument **210** in the preoperative implant device planning image **310**. When the instrument tip mark is moved to a position of the virtual surgical instrument pattern **320**, the preoperative implant device planning image **310** is changed to the skin incision and trajectory guiding picture **330** on the displaying device **300**.

The skin incision and trajectory guiding step S**15** is for moving the surgical instrument **210** by the user according to the skin incision and trajectory guiding picture **330** so as to move the instrument tip mark close to a planned surgical position **3362**, and the planned surgical position **3362** is displayed in the skin incision and trajectory guiding picture **330**, as shown in FIG. **3**B. The skin incision and trajectory guiding picture **330** includes a transverse plane **332**, a sagittal plane **334** and a skin incision aiming image **336**. The transverse plane **332** is defined by an area between an x-axis and a z-axis. The virtual surgical instrument pattern **320** and the instrument tip mark **2102** are displayed at a first viewing angle in the transverse plane **332**. The sagittal plane **334** is defined by an area between the z-axis and a y-axis. The x-axis, the y-axis and the z-axis define a surgical site coordinate system, and the virtual surgical instrument pattern **320** and the instrument tip mark **2102** are displayed at a second viewing angle in the sagittal plane **334**. The position of the virtual surgical instrument pattern **320** is corresponding to the planned surgical position **3362**. The skin incision aiming image **336** displays the instrument tip mark **2104** and the planned surgical position **3362**. The instrument tip mark **2102** of the transverse plane **332**, the instrument tip mark **2102** of the sagittal plane **334** and the instrument tip mark **2104** of the skin incision aiming image **336** are simultaneously moved with the movement of the surgical instrument **210** according to the surgical site coordinate system. In other words, the instrument tip mark **2102** of the transverse plane **332**, the instrument tip mark **2102** of the sagittal plane **334** and the instrument tip mark **2104** of the skin incision aiming image **336** are moved according to the movement of the surgical instrument **210** and respective coordinates. Additionally, in the skin incision aiming image **336** of the skin incision and trajectory guiding picture **330**, there is a distance between the instrument tip mark **2104** and the planned surgical position **3362**. When the distance is greater than a first predetermined distance value, the instrument tip mark **2104** is displayed in a first color being red. When the distance is smaller than or equal to the first predetermined distance value and greater than a second predetermined distance value, the instrument tip mark **2104** is displayed in a second color being yellow. When the distance is smaller than or equal to the second predetermined distance value, the instrument tip mark **2104** is displayed in a third color being green, so that the first color, the second color and the third color are different from each other. Furthermore, the skin incision and trajectory guiding step S**15** is for moving the surgical instrument **210** by the user to align the instrument tip mark **2104** with the planned surgical position **3362** in the skin incision and trajectory guiding picture **330**. When the instrument tip mark **2104** is fully aligned with the planned surgical position **3362** for a period of time (e.g., 0.5 seconds to 1 second), the skin incision and trajectory guiding picture **330** is changed to a surgical instrument guiding picture **340** on the displaying device **300**.

The surgical instrument trajectory guiding step S**16** is for moving a tip and a tail of the surgical instrument **210** close to the planned surgical position **3362** according to the surgical instrument guiding picture **340**, and then the tip and the tail of the surgical instrument **210** are simultaneously aligned with the planned surgical position **3362**, as shown in FIG. **3**C. The surgical instrument guiding picture **340** includes a transverse plane **342**, a sagittal plane **344** and an instrument aiming image **346**. The detail of the transverse plane **342** and the sagittal plane **344** are the same as the transverse plane **332** and the sagittal plane **334** of the skin incision and trajectory guiding picture **330**. The instrument aiming image **346** includes an instrument tip mark **2106**, an instrument tail mark **2108** and the planned surgical position **3362**, so that the surgical instrument guiding picture **340** displays the instrument tip mark **2106**, the instrument tail mark **2108** and the planned surgical position **3362**. The instrument tip mark **2106** is corresponding to the tip of the surgical instrument **210** and spaced from the planned surgical position **3362** by a tip distance. The instrument tail mark **2108** is corresponding to the tail of the surgical instrument **210** and spaced from the planned surgical position **3362** by a tail distance. When the tip distance is greater than the first predetermined distance value, the instrument tip mark **2106** is displayed in the first color being red. When the tail distance is greater than the first predetermined distance value, the instrument tail mark **2106** is displayed in the first color being red. When the tip distance is smaller than or equal to the first predetermined distance value and greater than the second predetermined distance value, the instrument tip mark **2106** is displayed in the second color being yellow. When the tail distance is smaller than or equal to the first predetermined distance value and greater than a second predetermined distance value, the instrument tail mark **2108** is displayed in the second color being yellow. When the tip distance is smaller than or equal to the second predetermined distance value, the instrument tip mark **2106** is displayed in the third color being green. When the tail distance is smaller than or equal to the second predetermined distance value, the instrument tail mark **2108** is displayed in the third color being green. The first color, the second color and the third color are different from each other. If the instrument tip mark **2106** and the instrument tail mark **2108** are both displayed in the green color, it represents that the user (physician) operates the surgical instrument **210** in the correct position. The first predetermined distance value and the second predetermined distance value can be freely set by the user according to requirements of the surgery. Therefore, the no-touch surgical navigation method **100** of the present disclosure uses plural specific steps to reduce redundant touch of the physician when the physician controls the surgical instrument **210** during the surgical procedure, thus improving convenience and efficiency of use.

In FIGS. **1**-**3**C, a no-touch surgical navigation system **102** using the no-touch surgical navigation method **100** can control the surgical instrument **210** to immediately move to the correct position. A body optical sensing device **120** is disposed on the part of the patient's anatomy **110**. The no-touch surgical navigation system **102** includes an instrument module **200**, a displaying device **300**, an optical tracker **400**, a calibrating device **500** and a processing unit **700**.

The instrument module **200** includes the surgical instrument **210** and the instrument optical sensing device **220**. The surgical instrument **210** is moved by the user and connected to the instrument optical sensing device **220**. The surgical instrument **210** may be the guiding probe, the bone screw or other surgical instrument according to the user's selection and requirement.

The displaying device **300** includes a screen which displays a preoperative implant device planning image **310**, a virtual surgical instrument pattern **320**, a skin incision and trajectory guiding picture **330** or a surgical instrument guiding picture **340**.

The optical tracker **400** is used for tracking the part of the patient's anatomy, the surgical instrument **210** and the calibrating device **500**. When the user (e.g., a physician) controls the surgical instrument **210**, the optical tracker **400** is configured to sense the instrument optical sensing device **220**, and the instrument optical sensing device **220** is oriented towards the optical tracker **400** so as to identify the surgical instrument **210** by the optical tracker **400** and obtain a surgical instrument datum corresponding to the surgical instrument **210**. The surgical instrument datum includes the type and specification of the surgical instrument **210**. In addition, the body optical sensing device **120** is also oriented towards the optical tracker **400** so as to identify the precision position of the part of the patient's anatomy **110** and the relative position between the part of the patient's anatomy **110** and the surgical instrument **210** by the optical tracker **400**.

The calibrating device **500** is detachably connected to the surgical instrument **210**. The calibrating device **500** has a plurality of calibrating holes which have different diameters. These different diameters range from about 2 mm to about 10.5 mm, and may be corresponding to various diameters of bone screws or guiding probes, as shown in FIG. **6**D. The calibrating optical sensing device **510** is disposed on the calibrating device **500** oriented towards the optical tracker **400**, thus identifying the precision position of the tip of the surgical instrument **210** via the optical tracker **400**. Moreover, if the instrument optical sensing device **220**, the calibrating optical sensing device **510** and the body optical sensing device **120** are simultaneously oriented towards the optical tracker **400**, the relative positions of the calibrating device **500**, the surgical instrument **210** and the preoperative implant device planning image **310** can be obtained by the optical tracker **400**.

The processing unit **700** is signally connected to the displaying device **300** and the optical tracker **400**. The processing unit **700** may be a computer, a cloud processor or a mobile device. The processing unit **700** includes a preoperative implant device planning module **710**, an image registration module **720**, an instrument checking module **730**, an implant device placement selecting module **740** and a trajectory guiding module **750**. The preoperative implant device planning module **710**, the image registration module **720**, an instrument checking module **730**, an implant device placement selecting module **740** or a trajectory guiding module **750** may be an integrated microchip or a microprocessor. Moreover, the preoperative implant device planning module **710** is utilized to perform the preoperative implant device planning step S**11**. The preoperative implant device planning module **710** is configured to acquire the preoperative implant device planning image **310** and visualize the preoperative implant device planning image **310** on the screen of the displaying device **300**. The image registration module **720** is utilized to perform the image registration step S**12** and is signally connected to the preoperative implant device planning module **710**. The image registration module **720** is configured to establish the spatial coordinate transformation relationship between the part of the patient's anatomy **110** and the preoperative implant device planning image **310**, and match the preoperative implant device planning image **310** and the part of the patient's anatomy **110** via the spatial coordinate transformation relationship. The instrument checking module **730** is utilized to perform the instrument checking step S**13** and is signally connected to the image registration module **720** and the screen of the displaying device **300**. The instrument checking module **730** is configured to receive the surgical instrument datum and identify a position of the surgical instrument **210** on the screen, and then calibrate the size of the surgical instrument to display the instrument tip mark of the surgical instrument **210** on the screen. Furthermore, the implant device placement selecting module **740** is utilized to perform the implant device placement selecting step S**14** and is signally connected to the instrument checking module **730** and the image registration module **720**. The implant device placement selecting module **740** is configured to select the virtual surgical instrument pattern **320** in the preoperative implant device planning image **310** by moving the instrument tip mark of the surgical instrument **210** so as to display the skin incision and trajectory guiding picture **330** on the screen of the displaying device **300**. The trajectory guiding module

750 is utilized to perform the skin incision and trajectory guiding step S15 and is signally connected to the instrument checking module 730 and the implant device placement selecting module 740. The trajectory guiding module 750 is configured to move the instrument tip mark 2106 close to the planned surgical position 3362 by moving the surgical instrument 210 according to the skin incision and trajectory guiding picture 330 on the screen. Hence, the no-touch surgical navigation system 102 can utilize plural kinds of optical sensing devices combined with the optical tracker 400 to reduce redundant touch of the physician when the physician controls the surgical instrument 210 during the surgical procedure, thereby improving convenience and efficiency of use. Additionally, the no-touch surgical navigation system 102 can use the instrument optical sensing device 220 cooperated with the calibrating device 500 to enhance accuracy and safety of the surgical instrument 210 operated by the physician.

FIG. 4 shows a flow chart of a no-touch surgical navigation method 100*a* for guiding a plurality of surgical instruments corresponding to a part of a patient's anatomy 110 according to a second embodiment of the present disclosure; FIG. 5A shows a schematic view of a no-touch surgical navigation system 102*a* for guiding the surgical instruments corresponding to the part of the patient's anatomy 110 according to the second embodiment of the present disclosure; FIG. 5B shows a schematic view of a first surgical instrument 210*a* cooperated with a calibrating device 500 according to the second embodiment of the present disclosure; FIG. 5C shows a schematic view of a second surgical instrument 210*b* cooperated with the calibrating device 500 according to the second embodiment of the present disclosure; FIG. 5D shows a block diagram of the no-touch surgical navigation system 102*a* according to the second embodiment of the present disclosure; FIG. 6A shows a schematic view of a preoperative implant device planning image 310 on a displaying device 300 according to the second embodiment of the present disclosure; FIG. 6B shows a schematic view of a skin incision and trajectory guiding picture 330 on the displaying device 300 according to the second embodiment of the present disclosure; FIG. 6C shows a schematic view of a surgical instrument guiding picture 340 on the displaying device 300 for guiding the first surgical instrument 210*a* according to the second embodiment of the present disclosure; FIG. 6D shows a schematic view of the surgical instrument guiding picture 340 on the displaying device 300 for checking the second surgical instrument 210*b* according to the second embodiment of the present disclosure; and FIG. 6E shows a schematic view of the surgical instrument guiding picture 340 on the displaying device 300 for guiding the second surgical instrument 210*b* according to the second embodiment of the present disclosure. The no-touch surgical navigation method 100*a* for guiding a plurality of surgical instruments corresponding to the part of the patient's anatomy 110. The surgical instruments include the first surgical instrument 210*a* and the second surgical instrument 210*b*. The first surgical instrument 210*a* is a guiding probe, and the second surgical instrument 210*b* is a bone screw. The no-touch surgical navigation method 100*a* provides a preoperative implant device planning step S21, an image registration step S22, a first instrument checking step S23, an implant device placement selecting step S24, a skin incision and trajectory guiding step S25, an instrument replacing step S26, a second instrument checking step S27 and a surgical instrument trajectory guiding step S28.

The preoperative implant device planning step S21 is for acquiring at least one preoperative implant device planning image 310 and visualizing the preoperative implant device planning image 310 on the displaying device 300. The detail of the preoperative implant device planning step S21 is the same as the preoperative implant device planning step S11 in FIG. 1.

The image registration step S22 is for establishing a spatial coordinate transformation relationship between the part of the patient's anatomy 110 and the preoperative implant device planning image 310, and matching the preoperative implant device planning image 310 and the part of the patient's anatomy 110 via the spatial coordinate transformation relationship. The detail of the image registration step S22 is the same as the image registration step S12 in FIG. 1.

The first instrument checking step S23 is for identifying the first surgical instrument 210*a*, and then calibrating a size of the first surgical instrument 210*a* to display a first instrument tip mark of the first surgical instrument 210*a* on the displaying device 300. The first instrument tip mark represents a mouse cursor on a screen. The first instrument checking step S23 provides a first instrument identifying step S232 and a first instrument calibrating step S234. The first instrument calibrating step S232 is for disposing a first instrument optical sensing device 220*a* on the first surgical instrument 210*a*, and the first instrument optical sensing device 220*a* is oriented towards an optical tracker 400 so as to identify the first surgical instrument 210*a* by the optical tracker 400, as shown in FIG. 5A. The first instrument calibrating step S234 is for disposing a calibrating optical sensing device 510 on the calibrating device 500, and then engaging the first surgical instrument 210*a* with the calibrating device 500, and orienting the first surgical instrument 210*a* and the calibrating device 500 towards the optical tracker 400. The first surgical instrument 210*a* and the calibrating device 500 are simultaneously identified by the optical tracker 400 to establish a spatial coordinate transformation relationship between a tip of the first surgical instrument 210*a* and the first instrument optical sensing device 220*a*. The reason why the first instrument checking step S23 is performed in the no-touch surgical navigation method 100*a* is that the tip of the first surgical instrument 210*a* may be skewed after being used for a certain period of time, and the first instrument checking step S23 can provide precise identification and calibration of the first surgical instrument 210*a* before a navigation procedure. The first surgical instrument 210*a* which has been identified and calibrated via the first instrument checking step S23 meets the stringent requirements of surgery and achieves the required accuracy so as to preserve the correctness and safety of surgery in the navigation procedure.

The implant device placement selecting step S24 is for moving the first surgical instrument 210*a* by the user, and the first instrument tip mark is synchronously moved with the first surgical instrument 210*a* to select a virtual second surgical instrument pattern 320*a* in the preoperative implant device planning image 310. Then, a skin incision and trajectory guiding picture 330 is shown on the displaying device 300, as shown in FIG. 6A. In other words, the implant device placement selecting step S24 is for moving the first surgical instrument 210*a* by the user to move the first instrument tip mark corresponding to a position of the tip of the first surgical instrument 210*a* in the preoperative implant device planning image 310. The first instrument tip mark represents a mouse cursor on the screen. When the first instrument tip mark is moved to a position of the virtual second surgical instrument pattern **320***a*, the preoperative implant device planning image **310** is changed to the skin incision and trajectory guiding picture **330** on the displaying device **300**. In FIG. **6**A, the virtual second surgical instrument pattern **320***a* is a virtual bone screw.

The skin incision and trajectory guiding step S**25** is for moving the first surgical instrument **210***a* by the user according to the skin incision and trajectory guiding picture **330** so as to move the first instrument tip mark **2104***a* close to a planned surgical position **3362**. The planned surgical position **3362** is displayed in the skin incision and trajectory guiding picture **330**, as shown in FIG. **6**B. When the first instrument tip mark **2104***a* is aligned with the planned surgical position **3362**, the skin incision and trajectory guiding picture **330** is changed to a surgical instrument guiding picture **340** on the displaying device **300**, as shown in FIG. **6**C. In detail, when the first instrument tip mark **2104***a* is fully aligned with the planned surgical position **3362** for a period of time, the skin incision and trajectory guiding picture **330** is changed to a surgical instrument guiding picture **340** on the displaying device **300**. Additionally, the skin incision and trajectory guiding picture **330** includes a transverse plane **332**, a sagittal plane **334** and a skin incision aiming image **336**. The transverse plane **332** is defined by an area between an x-axis and a z-axis. The virtual second surgical instrument pattern **320***a* and the first instrument tip mark **2102***a* are displayed at a first viewing angle in the transverse plane **332**. The sagittal plane **334** is defined by an area between the z-axis and a y-axis. The x-axis, the y-axis and the z-axis define a surgical site coordinate system, and the virtual second surgical instrument pattern **320***a* and the first instrument tip mark **2102***a* are displayed at a second viewing angle in the sagittal plane **334**. The skin incision aiming image **336** displays the first instrument tip mark **2104***a* and the planned surgical position **3362**. The first instrument tip mark **2102***a* of the transverse plane **332**, the first instrument tip mark **2102***a* of the sagittal plane **334** and the first instrument tip mark **2104***a* of the skin incision aiming image **336** are simultaneously moved with the movement of the first surgical instrument **210***a* according to the surgical site coordinate system, so that it is convenient and expeditious for the physician to know the relative position of the first surgical instrument **210***a* (i.e., the first instrument tip mark **2104***a*) and a target position (i.e., the planned surgical position **3362**) in the space. Moreover, in the skin incision and trajectory guiding picture **330**, there is a distance between the first instrument tip mark **2104***a* and the planned surgical position **3362**. When the distance is greater than a first predetermined distance value, the first instrument tip mark **2104***a* is displayed in a first color being red. When the distance is smaller than or equal to the first predetermined distance value and greater than a second predetermined distance value, the first instrument tip mark **2104***a* is displayed in a second color being yellow. When the distance is smaller than or equal to the second predetermined distance value, the first instrument tip mark **2104***a* is displayed in a third color being green. The size of the distance affects the color of the first instrument tip mark **2104***a*. In other words, the physician can immediately know the distance via the color of the first instrument tip mark **2104***a*. The red color represents that the distance is greater than the first predetermined distance value. The yellow color represents that the distance is smaller than or equal to the first predetermined distance value and greater than the second predetermined distance value. The green color represents that the distance is smaller than or equal to the second predetermined distance value. In FIG. **6**C, the surgical instrument guiding picture **340** displays a first instrument tip mark **2106***a*, a first instrument tail mark **2108***a* and the planned surgical position **3362**. The first instrument tip mark **2106***a* is corresponding to the tip of the first surgical instrument **210***a*. The first instrument tail mark **2108***a* is corresponding to the tail of the first surgical instrument **210***a*. The first instrument tip mark **2106***a* is spaced from the planned surgical position **3362** by a tip distance, and the first instrument tail mark **2108***a* is spaced from the planned surgical position **3362** by a tail distance. Accordingly, the skin incision and trajectory guiding step S**25** of the present disclosure uses the double marks combined with changeable colors to enable the physician to quickly and accurately move the first surgical instrument **210***a* to the target position, thereby substantially reducing operating time and improving the safety of surgery.

The instrument replacing step S**26** is for replacing the first surgical instrument **210***a* (i.e., the guiding probe) with the second surgical instrument **210***b* (i.e., the bone screw) by the user according to the virtual second surgical instrument pattern **320***a* of the implant device placement selecting step S**24**. The virtual second surgical instrument pattern **320***a* is corresponding to the second surgical instrument **210***b*. After the instrument replacing step S**26**, the first instrument tip mark **2106***a* and the first instrument tail mark **2108***a* of the surgical instrument guiding picture **340** are replaced with a second instrument tip mark **2106***b* and a second instrument tail mark **2108***b*, respectively, as shown in FIGS. **6**C and **6**E.

The second instrument checking step S**27** is for identifying the second surgical instrument **210***b*, and then calibrating a size of the second surgical instrument **210***b* to display a second instrument tip mark **2106***b* of the second surgical instrument **210***b* on the displaying device**300**, as shown in FIG. **6**D. In detail, the second instrument checking step S**27** provides a second instrument identifying step S**272** and a second instrument calibrating step S**274**. The second instrument identifying step S**272** is for disposing a second instrument optical sensing device **220***b* on the second surgical instrument **210***b*, and the second instrument optical sensing device **220***b* is oriented towards the optical tracker **400** so as to identify the second surgical instrument **210***b* by the optical tracker **400**. Furthermore, the second instrument identifying step S**272** is for disposing a radio frequency identification tag **620** (RFID tag) on the second surgical instrument **210***b* and driving a wireless signal receiver **610** (RFID reader) to sense the radio frequency identification tag **620** so as to identify the second surgical instrument **210***b* by the wireless signal receiver **610**, as shown in FIG. **6**D. In addition, the second instrument calibrating step S**274** is for disposing the calibrating optical sensing device **510** on the calibrating device **500**, and then engaging the second surgical instrument **210***b* with the calibrating device **500**. After that, the second instrument calibrating step S**274** is for orienting the second surgical instrument **210***b* and the calibrating device **500** towards the optical tracker **400**. When the second surgical instrument **210***b* is engaged with the calibrating device **500**, the physician corresponds the second surgical instrument **210***b* to one of plural holes of the calibrating device **500** having a most appropriate diameter. The most appropriate diameter is equal to or greater than the diameter of the second surgical instrument **210***b*, as shown in FIG. **6**D ("Select diameter"). Finally, the second surgical instrument **210***b* and the calibrating device **500** are simultaneously identified by the optical tracker **400** to establish a spatial coordinate transformation relationship between a tip of the second surgical instrument **210***b* and the second instrument optical sensing device **220***b*. The precise length of the second surgical instrument **210***b* can be also obtain, as shown in FIG. **6**D ("Screw length").

The surgical instrument trajectory guiding step S**28** is for moving the second surgical instrument **210***b* close to the planned surgical position **3362** according to the surgical instrument guiding picture **340**, as shown in FIG. **6**E. In detail, the surgical instrument trajectory guiding step S**28** is for moving the second surgical instrument **210***b* to fully align the second instrument tip mark **2106***b* and a second instrument tail mark **2108***b* with the planned surgical position **3362** according to the surgical instrument guiding picture **340**. The second instrument tip mark **2106***b* is corresponding to a tip of the second surgical instrument **210***b*, and the second instrument tail mark **2108***b* is corresponding to a tail of the second surgical instrument **210***b*. The surgical instrument guiding picture **340** displays the second instrument tip mark **2106***b*, the second instrument tail mark **2108***b* and the planned surgical position **3362**. The second instrument tip mark **2106***b* is spaced from the planned surgical position **3362** by a tip distance, and the second instrument tail mark **2108***b* is spaced from the planned surgical position **3362** by a tail distance. When the tip distance is greater than the first predetermined distance value, the second instrument tip mark **2106***b* is displayed in the red color. When the tail distance is greater than the first predetermined distance value, the second instrument tail mark **2108***b* is displayed in the red color. When the tip distance is smaller than or equal to the first predetermined distance value and greater than the second predetermined distance value, the second instrument tip mark **2106***b* is displayed in the yellow color. When the tail distance is smaller than or equal to the first predetermined distance value and greater than the second predetermined distance value, the second instrument tail mark **2108***b* is displayed in the yellow color. When the tip distance is smaller than or equal to the second predetermined distance value, the second instrument tip mark **2106***b* is displayed in the green color. When the tail distance is smaller than or equal to the second predetermined distance value, the second instrument tail mark **2108***b* is displayed in the green color. It is obvious that the red color, the yellow color and the green color are different from each other. If the physician can control the second surgical instrument **210***b* to maintain the green color in the second instrument tip mark **2106***b* and the second instrument tail mark **2108***b*, it represents that the second surgical instrument **210** is operated in the correct and ideal position, thus satisfying the preoperative planning path and condition.

In FIGS. **2**C, **5**A, **5**B, **5**C and **5**D, the no-touch surgical navigation system **102***a* is used for guiding the first surgical instrument **210***a* and the second surgical instrument **210***b* relative to the part of the patient's anatomy **110** by the no-touch surgical navigation method **100***a*. A body optical sensing device **120** is disposed on the part of the patient's anatomy **110**. The no-touch surgical navigation system **102***a* includes a first instrument module **200***a*, a second instrument module **200***b*, a displaying device **300**, an optical tracker **400**, a calibrating device **500**, a wireless signal receiver **610**, a radio frequency identification tag **620** and a processing unit **700**.

In FIG. **5**D, the detail of the displaying device **300**, the optical tracker **400**, the calibrating device **500** and the processing unit **700** are the same as the embodiment of FIG. **2**C. In FIG. **5**D, the no-touch surgical navigation system **102***a* further includes the first instrument module **200***a*, the second instrument module **200***b*, the wireless signal receiver **610** and the radio frequency identification tag **620**. The first instrument module **200***a* includes a first surgical instrument **210***a* and a first instrument optical sensing device **220***a*. The second instrument module **200***b* includes a second surgical instrument **210***b*, a second instrument optical sensing device **220***b*, an instrument assembly **230***b* and a grip **240***b*. In FIG. **5**A, the first surgical instrument **210***a* is a guiding probe, and the second surgical instrument **210***b* is a bone screw. The instrument assembly **230***b* is a bone screw assembly corresponding to the second surgical instrument **210***b*. The instrument assembly **230***b* is connected between the second surgical instrument **210***b* and the grip **240***b*. Moreover, the wireless signal receiver **610** is disposed adjacent to the optical tracker **400** and used for detecting the radio frequency identification tag **620**. The radio frequency identification tag **620** is disposed on the instrument assembly **230***b* and carries information of the corresponding type and specification of the second surgical instrument **210***b*. When the radio frequency identification tag **620** is aligned with the optical tracker **400** within a certain distance range, the wireless signal receiver **610** can identify the corresponding type and specification of the second surgical instrument **210***b*. Accordingly, the no-touch surgical navigation system **102***a* and the no-touch surgical navigation method **100***a* are used to freely replace the suitable surgical instrument under a no-touch condition according to surgical requirements, thereby improving convenience and efficiency and maintaining a high degree of accuracy and safety. The no-touch condition represents that the user does not touch the screen or control panels to adjust the parameters (e.g., the types and specifications of the surgical instruments) of the no-touch surgical navigation system **102***a*, so that the surgical instruments can automatically identified and calibrated by the no-touch surgical navigation method **100***a* during the surgical procedure. The no-touch surgical navigation system **102***a* and the no-touch surgical navigation method **100***a* are suitable for use in surgery to solve the problems of the conventional navigation system and method that require the user to additionally touch the screen or control panels to adjust the parameters during the surgical procedure.

According to the aforementioned embodiments and examples, the advantages of the present disclosure are described as follows.

1. The no-touch surgical navigation method and the no-touch surgical navigation system thereof of the present disclosure can utilize plural kinds of optical sensing devices combined with the optical tracker to reduce redundant touch of the physician when the physician controls the surgical instruments during the surgical procedure, thereby improving convenience and efficiency of use.

2. The no-touch surgical navigation method and the no-touch surgical navigation system thereof of the present disclosure can use the double marks combined with changeable colors to enable the physician to quickly and accurately move the surgical instrument to the target position, thereby substantially reducing operating time and improving the safety of surgery.

3. The no-touch surgical navigation system and the no-touch surgical navigation system thereof of the present disclosure can use the instrument optical sensing device cooperated with the calibrating device to enhance accuracy and safety of the surgical instrument operated by the physician.

Although the present disclosure has been described in considerable detail with reference to certain embodiments thereof, other embodiments are possible. Therefore, the spirit and scope of the appended claims should not be limited to the description of the embodiments contained herein.

It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present disclosure without departing from the scope or spirit of the disclosure. In view of the foregoing, it is intended that the present disclosure cover modifications and variations of this disclosure provided they fall within the scope of the following claims.

What is claimed is:

1. A no-touch surgical navigation method for guiding a surgical instrument corresponding to a part of a patient's anatomy, the no-touch surgical navigation method comprising:

providing a preoperative implant device planning step, wherein the preoperative implant device planning step is for acquiring at least one preoperative implant device planning image and visualizing the preoperative implant device planning image on a displaying device;

providing an image registration step, wherein the image registration step is for establishing a spatial coordinate transformation relationship between the part of the patient's anatomy and the preoperative implant device planning image, and matching the preoperative implant device planning image and the part of the patient's anatomy via the spatial coordinate transformation relationship;

providing an instrument checking step, wherein the instrument checking step is for identifying the surgical instrument, and then calibrating a size of the surgical instrument to display an instrument tip mark of the surgical instrument on the displaying device;

providing an implant device placement selecting step, wherein the implant device placement selecting step is for moving the surgical instrument by a user, and the instrument tip mark is synchronously moved with the surgical instrument to select a virtual surgical instrument pattern in the preoperative implant device planning image, and then a skin incision and trajectory guiding picture is shown on the displaying device; and

providing a skin incision and trajectory guiding step, wherein the skin incision and trajectory guiding step is for moving the surgical instrument by the user according to the skin incision and trajectory guiding picture so as to move the instrument tip mark close to a planned surgical position, and the planned surgical position is displayed in the skin incision and trajectory guiding picture.

2. The no-touch surgical navigation method of claim **1**, wherein,

the preoperative implant device planning image includes a preoperative patient anatomical image; and

the image registration step is for driving a radiographic image capturing system to capture an intraoperative patient anatomical image corresponding to the part of the patient's anatomy and disposing a radiographic optical sensing device on the radiographic image capturing system, a body optical sensing device is disposed on the part of the patient's anatomy, the radiographic optical sensing device and the body optical sensing device are both oriented towards an optical tracker to establish the spatial coordinate transformation relationship between the part of the patient's anatomy and the preoperative implant device planning image, the preoperative patient anatomical image is corresponding to the intraoperative patient anatomical image via the spatial coordinate transformation relationship.

3. The no-touch surgical navigation method of claim **1**, wherein the instrument checking step comprising:

providing an instrument identifying step, wherein the instrument identifying step is for disposing an instrument optical sensing device on the surgical instrument, and the instrument optical sensing device is oriented towards an optical tracker so as to identify the surgical instrument by the optical tracker.

4. The no-touch surgical navigation method of claim **3**, wherein,

the instrument identifying step is for disposing a radio frequency identification tag on the surgical instrument and driving a wireless signal receiver to sense the radio frequency identification tag so as to identify the surgical instrument by the wireless signal receiver.

5. The no-touch surgical navigation method of claim **3**, wherein the instrument checking step further comprising:

providing an instrument calibrating step, wherein the instrument calibrating step is for disposing a calibrating optical sensing device on a calibrating device, and then engaging the surgical instrument with the calibrating device, and orienting the surgical instrument and the calibrating device towards the optical tracker, the surgical instrument and the calibrating device are simultaneously identified by the optical tracker to establish a spatial coordinate transformation relationship between a tip of the surgical instrument and the instrument optical sensing device.

6. The no-touch surgical navigation method of claim **5**, wherein,

the implant device placement selecting step is for moving the surgical instrument by the user to move the instrument tip mark corresponding to a position of the tip of the surgical instrument in the preoperative implant device planning image, and when the instrument tip mark is moved to a position of the virtual surgical instrument pattern, the preoperative implant device planning image is changed to the skin incision and trajectory guiding picture on the displaying device.

7. The no-touch surgical navigation method of claim **1**, wherein the skin incision and trajectory guiding picture comprises:

a transverse plane defined by an area between an x-axis and a z-axis, wherein the virtual surgical instrument pattern and the instrument tip mark are displayed at a first viewing angle in the transverse plane;

a sagittal plane defined by an area between the z-axis and a y-axis, wherein the x-axis, the y-axis and the z-axis define a surgical site coordinate system, and the virtual surgical instrument pattern and the instrument tip mark are displayed at a second viewing angle in the sagittal plane; and

a skin incision aiming image displaying the instrument tip mark and the planned surgical position;

wherein the instrument tip mark of the transverse plane, the instrument tip mark of the sagittal plane and the instrument tip mark of the skin incision aiming image are simultaneously moved with movement of the surgical instrument according to the surgical site coordinate system.

8. The no-touch surgical navigation method of claim **1**, wherein,

in the skin incision and trajectory guiding picture, there is a distance between the instrument tip mark and the planned surgical position;

wherein when the distance is greater than a first predetermined distance value, the instrument tip mark is displayed in a first color;

wherein when the distance is smaller than or equal to the first predetermined distance value and greater than a second predetermined distance value, the instrument tip mark is displayed in a second color;

wherein when the distance is smaller than or equal to the second predetermined distance value, the instrument tip mark is displayed in a third color, and the first color, the second color and the third color are different from each other.

9. The no-touch surgical navigation method of claim **1**, wherein,

the skin incision and trajectory guiding step is for moving the surgical instrument by the user to align the instrument tip mark with the planned surgical position in the skin incision and trajectory guiding picture, and when the instrument tip mark is fully aligned with the planned surgical position for a period of time, the skin incision and trajectory guiding picture is changed to a surgical instrument guiding picture on the displaying device.

10. The no-touch surgical navigation method of claim **9**, further comprising:

providing a surgical instrument trajectory guiding step, wherein the surgical instrument trajectory guiding step is for moving a tip and a tail of the surgical instrument close to the planned surgical position according to the surgical instrument guiding picture, and then the tip and the tail of the surgical instrument are simultaneously aligned with the planned surgical position.

11. The no-touch surgical navigation method of claim **10**, wherein,

the surgical instrument guiding picture displays the instrument tip mark, an instrument tail mark and the planned surgical position, the instrument tail mark is corresponding to the tail of the surgical instrument, the instrument tip mark is spaced from the planned surgical position by a tip distance, and the instrument tail mark is spaced from the planned surgical position by a tail distance;

wherein when the tip distance is greater than a first predetermined distance value, the instrument tip mark is displayed in a first color;

wherein when the tail distance is greater than the first predetermined distance value, the instrument tail mark is displayed in the first color;

wherein when the tip distance is smaller than or equal to the first predetermined distance value and greater than a second predetermined distance value, the instrument tip mark is displayed in a second color;

wherein when the tail distance is smaller than or equal to the first predetermined distance value and greater than a second predetermined distance value, the instrument tail mark is displayed in the second color;

wherein when the tip distance is smaller than or equal to the second predetermined distance value, the instrument tip mark is displayed in a third color;

wherein when the tail distance is smaller than or equal to the second predetermined distance value, the instrument tail mark is displayed in the third color, and the first color, the second color and the third color are different from each other.

12. The no-touch surgical navigation method of claim **1**, wherein,

the skin incision and trajectory guiding step is for moving the first surgical instrument by the user to align the first instrument tip mark with the planned surgical position in the skin incision and trajectory guiding picture, and when the first instrument tip mark is fully aligned with the planned surgical position for a period of time, the skin incision and trajectory guiding picture is changed to a surgical instrument guiding picture on the displaying device.

13. A no-touch surgical navigation system using the no-touch surgical navigation method of claim **1**, comprising:

the surgical instrument moved by the user and connected to an instrument optical sensing device;

the displaying device comprising a screen which displays the preoperative implant device planning image, the skin incision and trajectory guiding picture or a surgical instrument guiding picture;

an optical tracker configured to sense the instrument optical sensing device, wherein the instrument optical sensing device is oriented towards the optical tracker so as to identify the surgical instrument by the optical tracker and obtain a surgical instrument datum corresponding to the surgical instrument; and

a processing unit signally connected to the displaying device and the optical tracker, and the processing unit comprising:

a preoperative implant device planning module configured to acquire the preoperative implant device planning image and visualize the preoperative implant device planning image on the screen;

an image registration module signally connected to the preoperative implant device planning module, wherein the image registration module is configured to establish the spatial coordinate transformation relationship between the part of the patient's anatomy and the preoperative implant device planning image, and match the preoperative implant device planning image and the part of the patient's anatomy via the spatial coordinate transformation relationship;

an instrument checking module signally connected to the image registration module and the screen, wherein the instrument checking module is configured to receive the surgical instrument datum and identify a position of the surgical instrument on the screen, and then calibrate the size of the surgical instrument to display the instrument tip mark of the surgical instrument on the screen;

an implant device placement selecting module signally connected to the instrument checking module and the image registration module, wherein the implant device placement selecting module is configured to select a virtual surgical instrument pattern in the preoperative implant device planning image by moving the instrument tip mark of the surgical instrument so as to display the skin incision and trajectory guiding picture on the screen; and

a trajectory guiding module signally connected to the instrument checking module and the implant device placement selecting module, wherein the trajectory guiding module is configured to move the instrument tip mark close to a planned surgical position by moving the surgical instrument according to the skin incision and trajectory guiding picture on the screen.

14. The no-touch surgical navigation system of claim **13**, further comprising:

a calibrating device detachably connected to the surgical instrument; and

a calibrating optical sensing device disposed on the calibrating device oriented towards the optical tracker;

wherein the instrument optical sensing device and the calibrating optical sensing device are oriented towards the optical tracker so as to obtain relative positions of the calibrating device, the surgical instrument and the preoperative implant device planning image by the optical tracker.

15. A no-touch surgical navigation method for guiding a plurality of surgical instruments corresponding to a part of the patient's anatomy, the surgical instruments comprising a first surgical instrument and a second surgical instrument, the no-touch surgical navigation method comprising:

providing a preoperative implant device planning step, wherein the preoperative implant device planning step is for acquiring at least one preoperative implant device planning image and visualizing the preoperative implant device planning image on a displaying device;

providing an image registration step, wherein the image registration step is for establishing a spatial coordinate transformation relationship between the part of the patient's anatomy and the preoperative implant device planning image, and matching the preoperative implant device planning image and the part of the patient's anatomy via the spatial coordinate transformation relationship;

providing a first instrument checking step, wherein the first instrument checking step is for identifying the first surgical instrument, and then calibrating a size of the first surgical instrument to display a first instrument tip mark of the first surgical instrument on the displaying device;

providing an implant device placement selecting step, wherein the implant device placement selecting step is for moving the first surgical instrument by a user, and the first instrument tip mark is synchronously moved with the first surgical instrument to select a virtual second surgical instrument pattern in the preoperative implant device planning image, and then a skin incision and trajectory guiding picture is shown on the displaying device;

providing a skin incision and trajectory guiding step, wherein the skin incision and trajectory guiding step is for moving the first surgical instrument by the user according to the skin incision and trajectory guiding picture so as to move the first instrument tip mark close to a planned surgical position, the planned surgical position is displayed in the skin incision and trajectory guiding picture, and when the first instrument tip mark is aligned with the planned surgical position, the skin incision and trajectory guiding picture is changed to a surgical instrument guiding picture on the displaying device;

providing an instrument replacing step, wherein the instrument replacing step is for replacing the first surgical instrument with the second surgical instrument by the user;

providing a second instrument checking step, wherein the second instrument checking step is for identifying the second surgical instrument, and then calibrating a size of the second surgical instrument to display a second instrument tip mark of the second surgical instrument on the displaying device; and

providing a surgical instrument trajectory guiding step, wherein the surgical instrument trajectory guiding step is for moving the second surgical instrument close to the planned surgical position according to the surgical instrument guiding picture.

16. The no-touch surgical navigation method of claim 15, wherein,

the preoperative implant device planning image includes a preoperative patient anatomical image; and

the image registration step is for driving a radiographic image capturing system to capture an intraoperative patient anatomical image corresponding to the part of the patient's anatomy and disposing a radiographic optical sensing device on the radiographic image capturing system, a body optical sensing device is disposed on the part of the patient's anatomy, the radiographic optical sensing device and the body optical sensing device are both oriented towards an optical tracker to establish the spatial coordinate transformation relationship between the part of the patient's anatomy and the preoperative implant device planning image, the preoperative patient anatomical image is corresponding to the intraoperative patient anatomical image via the spatial coordinate transformation relationship.

17. The no-touch surgical navigation method of claim 15, wherein the first instrument checking step comprising:

providing a first instrument identifying step, wherein the first instrument identifying step is for disposing a first instrument optical sensing device on the first surgical instrument, and the first instrument optical sensing device is oriented towards an optical tracker so as to identify the first surgical instrument by the optical tracker.

18. The no-touch surgical navigation method of claim 17, wherein the first instrument checking step further comprising:

providing a first instrument calibrating step, wherein the first instrument calibrating step is for disposing a calibrating optical sensing device on a calibrating device, and then engaging the first surgical instrument with the calibrating device, and orienting the first surgical instrument and the calibrating device towards the optical tracker, the first surgical instrument and the calibrating device are simultaneously identified by the optical tracker to establish a spatial coordinate transformation relationship between a tip of the first surgical instrument and the first instrument optical sensing device.

19. The no-touch surgical navigation method of claim 18, wherein,

the implant device placement selecting step is for moving the first surgical instrument by the user to move the first instrument tip mark corresponding to a position of the tip of the first surgical instrument in the preoperative implant device planning image, and when the first instrument tip mark is moved to a position of the virtual second surgical instrument pattern, the preoperative implant device planning image is changed to the skin incision and trajectory guiding picture on the displaying device.

20. The no-touch surgical navigation method of claim 15, wherein the skin incision and trajectory guiding picture comprises:

a transverse plane defined by an area between an x-axis and a z-axis, wherein the virtual second surgical instrument pattern and the first instrument tip mark are displayed at a first viewing angle in the transverse plane;

a sagittal plane defined by an area between the z-axis and a y-axis, wherein the x-axis, the y-axis and the z-axis define a surgical site coordinate system, and the virtual second surgical instrument pattern and the first instrument tip mark are displayed at a second viewing angle in the sagittal plane; and

a skin incision aiming image displaying the first instrument tip mark and the planned surgical position;

wherein the first instrument tip mark of the transverse plane, the first instrument tip mark of the sagittal plane and the first instrument tip mark of the skin incision aiming image are simultaneously moved with movement of the first surgical instrument according to the surgical site coordinate system.

21. The no-touch surgical navigation method of claim **15**, wherein,

in the skin incision and trajectory guiding picture, there is a distance between the first instrument tip mark and the planned surgical position;

wherein when the distance is greater than a first predetermined distance value, the first instrument tip mark is displayed in a first color;

wherein when the distance is smaller than or equal to the first predetermined distance value and greater than a second predetermined distance value, the first instrument tip mark is displayed in a second color;

wherein when the distance is smaller than or equal to the second predetermined distance value, the first instrument tip mark is displayed in a third color, and the first color, the second color and the third color are different from each other.

22. The no-touch surgical navigation method of claim **15**, wherein the second instrument checking step comprising:

providing a second instrument identifying step, wherein the second instrument identifying step is for disposing a second instrument optical sensing device on the second surgical instrument, and the second instrument optical sensing device is oriented towards an optical tracker so as to identify the second surgical instrument by the optical tracker.

23. The no-touch surgical navigation method of claim **22**, wherein,

the second instrument identifying step is for disposing a radio frequency identification tag on the second surgical instrument and driving a wireless signal receiver to sense the radio frequency identification tag so as to identify the second surgical instrument by the wireless signal receiver.

24. The no-touch surgical navigation method of claim **22**, wherein the second instrument checking step further comprising:

providing a second instrument calibrating step, wherein the second instrument calibrating step is for disposing a calibrating optical sensing device on a calibrating device, and then engaging the second surgical instrument with the calibrating device, and orienting the second surgical instrument and the calibrating device towards the optical tracker, the second surgical instrument and the calibrating device are simultaneously identified by the optical tracker to establish a spatial coordinate transformation relationship between a tip of the second surgical instrument and the second instrument optical sensing device.

25. The no-touch surgical navigation method of claim **15**, wherein,

the surgical instrument guiding picture displays the second instrument tip mark, a second instrument tail mark and the planned surgical position, the second instrument tail mark is corresponding to a tail of the second surgical instrument, the second instrument tip mark is spaced from the planned surgical position by a tip distance, and the second instrument tail mark is spaced from the planned surgical position by a tail distance;

wherein when the tip distance is greater than a first predetermined distance value, the second instrument tip mark is displayed in a first color;

wherein when the tail distance is greater than the first predetermined distance value, the second instrument tail mark is displayed in the first color;

wherein when the tip distance is smaller than or equal to the first predetermined distance value and greater than a second predetermined distance value, the second instrument tip mark is displayed in a second color;

wherein when the tail distance is smaller than or equal to the first predetermined distance value and greater than the second predetermined distance value, the second instrument tail mark is displayed in the second color;

wherein when the tip distance is smaller than or equal to the second predetermined distance value, the second instrument tip mark is displayed in a third color;

wherein when the tail distance is smaller than or equal to the second predetermined distance value, the second instrument tail mark is displayed in the third color, and the first color, the second color and the third color are different from each other.

26. The no-touch surgical navigation method of claim **15**, wherein,

the surgical instrument trajectory guiding step is for moving the second surgical instrument to fully align the second instrument tip mark and a second instrument tail mark with the planned surgical position according to the surgical instrument guiding picture, the second instrument tip mark is corresponding to a tip of the second surgical instrument, and the second instrument tail mark is corresponding to a tail of the second surgical instrument.

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